

CIRCULATING ISSUE

FORTY-SEVENTH ANNUAL MEETING, PALMER HOUSE, CHICAGO
NOVEMBER 26-DECEMBER 1, 1961

Med.!

RADIOLOGY

A MONTHLY JOURNAL DEVOTED
TO CLINICAL RADIOLOGY AND
ALLIED SCIENCES



DARTMOUTH COLLEGE
OCT 2 1961

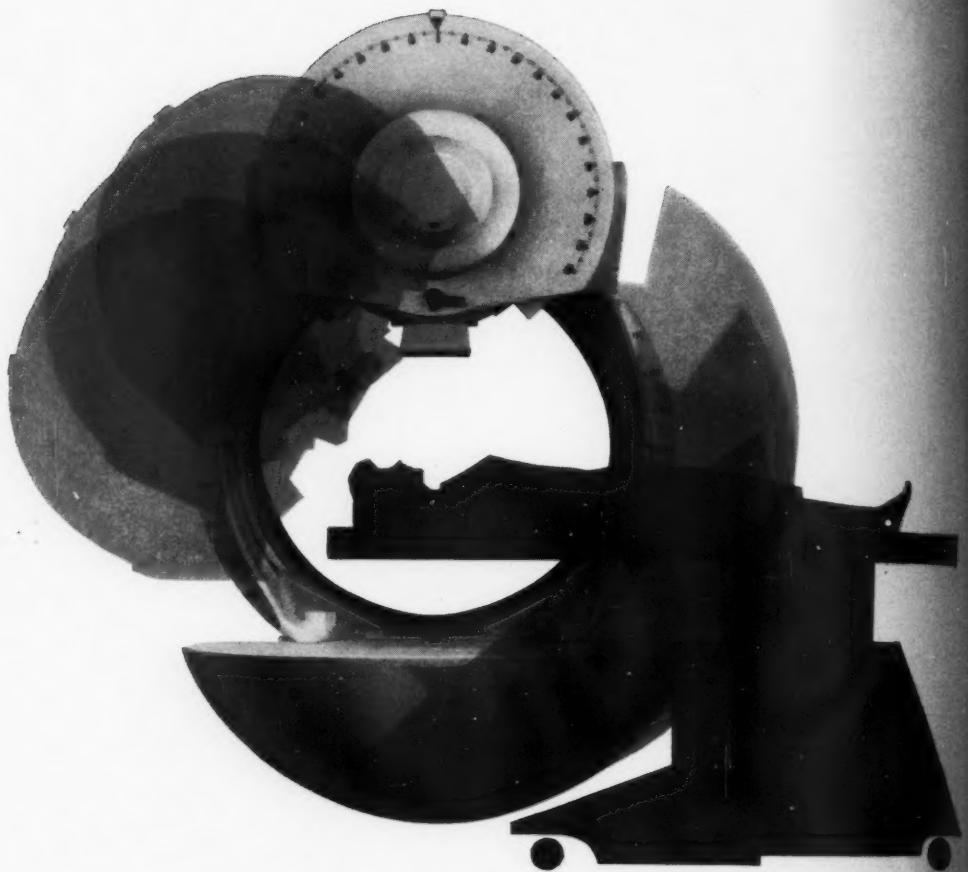
LIBRARY

SEPTEMBER · 1961

VOLUME 77

NUMBER 3

Owned and Published as its Official Journal by
THE RADILOGICAL SOCIETY OF NORTH AMERICA



Advanced new Westinghouse control design brings significant advantages to the Cobalt 60 Ring. It features a new automatic arc-speed computer requiring only arc and time settings. Whisper-quiet rotational drive, with exclusive patient contact protection, precisely follows control directions. Positive collimation turret, versatile ring and table are smartly styled in ivory and gold. For more information: Westinghouse X-Ray Department, 2519 Wilkens Ave., Baltimore 3, Md. You can be sure... if it's

Westinghouse



brings
it fea-
quiring
national
, pre-
nation
plied in
house
ore 3,
ouse



RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

Vol. 77

SEPTEMBER 1961

No. 3

CONTENTS

NONSPECIFIC SPONDYLITIS OF INFANTS AND CHILDREN.

Robert C. Jamison, M.D., Ernest M. Heimlich, M.D., John C. Miethke, M.D., and Bernard J. O'Loughlin, M.D. 355

OSTEITIS DEFORMANS (PAGET'S DISEASE OF BONE). A MORPHOLOGIC STUDY UTILIZING MICRORADIOGRAPHY AND CONVENTIONAL TECHNICS.

Patrick J. Kelly, M.D., Lowell F. A. Peterson, M.D., David C. Dahlén, M.D., and George E. Plum, M.D. 368

COMPARISON OF INTRASSEOUS VERTEBRAL VENOGRAPHY AND PANTOPAQUIS MYELOGRAPHY IN THE DIAGNOSIS OF SURGICAL CONDITIONS OF THE LUMBAR SPINE AND NERVE ROOTS.

Robert A. Schobinger, M.D., Erich G. Krueger, M.D., and Garrison L. Sobel, M.D. 376

ANGIOPHASIC INVESTIGATION OF CEREBROVASCULAR INSUFFICIENCY.

Hillier L. Baker, Jr., M.D. 399

ANTEROGRADE AORTOGRAPHY AND ARTERIOGRAPHY. FURTHER EXPERIENCE WITH THE METHOD. ITS PLACE IN ARTERIAL OPACIFICATION TECHNICS.

Lieut.-Col. Longstreet C. Hamilton, MC, USA, and Capt. William V. Weldon, MC, USA 406

NEW TECHNIC FOR ACCURATELY PROJECTING THE DORSUM SELLAE INTO THE FORAMEN MAGNUM.

Lewis E. Etter, M.D., F.A.C.R. 418

CIRCULATORY ARREST: MANUAL AND MECHANICAL MEANS FOR EMERGENCY MANAGEMENT.

Charles T. Dotter, M.D., Kurt R. Straube, M.D., and Douglas C. Strain, B.S. 426

SOME ASPECTS OF PULMONARY DYNAMICS REVEALED BY CONCURRENT ROENTGEN Kymography of Spirometric Movements and Diaphragmatic Excursions.

Elliott C. Lasser, M.D. 434

THE LOWER URINARY TRACT IN INFANTS AND CHILDREN.

Lawrence A. Davis, M.D., Robert Lich, M.D., Lonnie Howerton, M.D., and William Joule, M.D. 445

EARLY PHYSIOLOGIC NEPHRO-UROGRAPHY AS A TEST OF KIDNEY FUNCTION.

Richard L. Siggers, M.D. 452

CALCULATION OF THE DOSE DISTRIBUTION IN CIRCUMAXIAL ROTATION THERAPY WITH 280-KVP RADIATION.

H. F. Batho, Ph.D., and M. E. J. Young, M.Sc. 458

THE TREATMENT OF ADVANCED CARCINOMA OF THE BLADDER. A REPORT ON 89 PATIENTS TREATED WITH EITHER TWO-MILLION-VOLT OR COBALT-60 THERAPY OR WITH A COMBINATION OF THIS TYPE OF IRRADIATION AND SURGERY.

Ruth Guttmann, M.D., and Antonio Bauza, M.D. 465

COMPARISON OF THE LIGHT OUTPUT OF IMAGE-INTENSIFIER TUBES.

George C. Henny, M.D., and Joshua A. Becker, M.D. 472

A TECHNIC FOR CROSS-CALIBRATION OF X-RAY UNITS UTILIZING HALF-VALUE-LAYER DETERMINATIONS.

Leon Pape, M.S., S. Baker, R.T., and Hyman L. Gildenhorn, M.D. 480

MODIFICATION OF RADIATION RESPONSES OF TISSUE BY COLCHICINE. EFFECTS ON MOUSE HAIR ROOTS.

Melvin L. Griem, M.D., Frederick D. Malkinson, M.D., and Peter H. Morse, A.B. 486

WORK IN PROGRESS. THE DESIGN OF METALLIC TIP CATHETERS.

Robert M. Lowman, M.D., and Colin M. Bloor, M.D. 493

EDITORIAL: FORTY-SEVENTH ANNUAL MEETING, THE RADIOLOGICAL SOCIETY OF NORTH AMERICA.

H. Milton Berg, M.D. 496

RADIOLOGY REFRESHER COURSES: POSTGRADUATE INSTRUCTION, SOUTHERN MEDICAL ASSOCIATION.

498

ANNOUNCEMENTS AND BOOK REVIEWS.

501

IN MEMORIAM: WILLIAM HENRY MEYER, M.D.

505

ABSTRACTS OF CURRENT LITERATURE.

506

RADIOLOGY

A MONTHLY PUBLICATION DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES
PUBLISHED BY THE RADILOGICAL SOCIETY OF NORTH AMERICA, INC.

ASSOCIATE EDITORS

Leo G. Rigler, M.D.
Laurence L. Robbins, M.D.
Harold W. Jacox, M.D.
William R. Eyler, M.D.

PUBLICATION COMMITTEE

John A. Evans, M.D., Chairman
William T. Moss, M.D.
John L. McClenahan, M.D.

EDITOR

HOWARD P. DOUB, M.D.
Henry Ford Hospital, Detroit 2, Mich.

EDITORIAL ASSISTANTS

Marion B. Crowell, A.B.
Florence Roper Jeffery, A.B.
Arlene W. Hippie, A.B.

ADVISORY EDITORIAL BOARD

Richard H. Chamberlain, M.D.
Edith H. Quimby, Sc.D.
Arthur Purdy Stout, M.D.
Donald S. Childs, Jr., M.D.
Robert P. Barden, M.D.
F. Stephen Vogel, M.D.

GENERAL INFORMATION

Second-class mail privileges authorized at Syracuse, New York with additional entry at Easton, Pennsylvania. Acceptance for mailing at a special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized November 24, 1934. RADIOLOGY is published by the Radiological Society of North America as its official Journal. Publication office, 20th and Northampton Streets, Easton, Pa. Subscription rate \$15.00 per annum. Canadian postage, \$1.00 additional. Foreign postage, \$2.50 additional. Single copies \$2.50 each. All correspondence relative to business matters connected with the Radiological Society of North America and RADIOLOGY, or remittance for non-member subscriptions, should be made payable to The Radiological Society of North America, Inc., and should be addressed to the BUSINESS MANAGER, RADIOLOGY, 713 E. GENESSEE STREET, SYRACUSE 2, NEW YORK. In requesting change of address, both the old and the new address should be given.

Dues to The Radiological Society of North America include subscription to RADIOLOGY and should be paid to Dwight V. Needham, M.D., TREASURER of The Radiological Society of North America, Inc., 713 E. GENESSEE STREET, SYRACUSE 2, NEW YORK.

Inquiries regarding the program for the Annual Meeting of the Society for the current year should be sent to the President.

RADIOLOGY is published under the supervision of the Publication Committee of the Radiological Society of North America, which reserves the right to reject any material submitted for publication, including advertisements. No responsibility is accepted by the Committee or the Editor for the opinions expressed by the contributors, but the right is reserved to introduce such changes as may be necessary to make the contributions

conform to the editorial standards of RADIOLOGY. Correspondence relating to publication of papers should be addressed to the EDITOR, HOWARD P. DOUB, M.D., HENRY FORD HOSPITAL, DETROIT 2, MICHIGAN.

Original articles will be accepted only with the understanding that they are contributed solely to RADIOLOGY. Articles in foreign languages will be translated if they are acceptable. Manuscripts should be typewritten double-spaced, with wide margins, on good paper, and the original, not a carbon copy, should be submitted. The author's full address should appear on the manuscript. It is advisable that a copy be retained for reference as manuscripts will not be returned.

Illustrations and tables should be kept within reasonable bounds, as the number which can be published without cost to the author is strictly limited. For excess figures and for illustrations in color, estimates will be furnished by the Editor. Photographic prints should be clear and distinct and on glossy paper. Drawings and charts should be in India ink on white or on blue-lined coordinate paper. Blueprints will not reproduce satisfactorily. All photographs and drawings should be numbered, the top should be indicated, and each should be accompanied by a legend with a corresponding number. Authors are requested to indicate on prints made from photomicrographs the different types of cells to which attention is directed, by drawing lines in India ink and writing in the margin. The lines will be reproduced, and the words will be set in type. Attention should be called to points which should be brought out in completed illustrations, by tracings and suitable texts. These instructions should be concise and clear.

As a convenience to contributors to RADIOLOGY who are unable to supply prints for their manuscripts, the Editor can arrange for intermediate prints from roentgenograms.

Contents of RADIOLOGY copyrighted 1961 by The Radiological Society of North America, Inc.

RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES
PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

Vol. 77

SEPTEMBER 1961

No. 3

Nonspecific Spondylitis of Infants and Children¹

ROBERT C. JAMISON, M.D., ERNEST M. HEIMLICH, M.D., JOHN C. MIETHKE, M.D.,
and BERNARD J. O'LOUGHLIN, M.D.

IT IS OUR PURPOSE to present 6 cases of self-limited spondylitis of infants and children. All were characterized by failure to identify a specific infectious agent, a mild clinical course, positive roentgen findings, and recovery without antibiotics. The radiographic findings were indistinguishable from those of pyogenic osteomyelitis of the spine.

In 1950 Saenger reported 4 cases of spondylarthritis in children, with systemic signs of infection but negative diagnostic tests for a specific infective agent (16). The radiographic changes, consisting in narrowing of an intervertebral disk space and mild destructive lesions in the contiguous surfaces of the involved vertebral bodies, were progressive for one to two months and then regressed over another two to eight months, with only partial restoration of a normal picture. Saenger pointed out that Smith had reported a group of similar cases in 1933 in adults. Reference was also made to a paper by Ghormley *et al.* in 1940 (7), in which an analogous syndrome was described under the title "Acute Infectious Lesions of the Intervertebral Disks," but again most of the patients were adults.

Dupont and Andersen (5), in 1956, reported 4 cases of what they called "nonspecific spondylitis in childhood," with an age range from twenty-one

months to nine years. The illness pursued a subacute course and manifested the same radiographic changes and time sequence as Saenger's cases. Dupont and Andersen also emphasized the four clinical syndromes which spondylitis may assume. The first and most usual is back pain with spinal muscle spasm; the second is the hip joint or hip-leg syndrome with limitation of weight-bearing due to pain in the hip or leg plus flexion contracture of the thigh; the third is the abdomen-chest syndrome; the fourth is the meningeal, with stiff neck and positive Kernig or Brudzinski tests. The cases of Dupont and Andersen also yielded no proof of a specific etiology.

The 6 cases which we have encountered in the past five years will be briefly reviewed and compared with those reported by Saenger and Dupont and Andersen. The accompanying tables include a fourth series reported by Bremner and Neligan in the *British Medical Journal* under the title "Benign Form of Acute Osteitis of the Spine in Young Children" (1).

Some of the features of the previously mentioned groups of cases are compared with our series, from the University of California at Los Angeles, in Table I. As seen here, the sex incidence was equal in all series. This is in contrast to pyogenic osteomyelitis of the spine which has

¹ From the University of California Medical Center, Los Angeles, Calif. Presented at the Forty-sixth Annual Meeting of the Radiological Society of North America, Cincinnati, Ohio, Dec. 4-9, 1960.

TABLE I: NONSPECIFIC SPONDYLITIS OF INFANCY AND CHILDHOOD

	Saenger	Bremner & Neligan	Dupont & Andersen	Authors' Series (UCLA)
No. of cases	4	7	4	6
Sex	2M, 2F	not given*	2M, 2F	3M, 3F
Age	2-14 yr.	9 mo.-2 1/2 yr.	21 mo.-8 1/2 yr.	7 mo.-13 yr.
Syndrome				
Back	1	1	1	1
Hip-leg	2	4	1	3
Abdomen-chest	0	1	1	2
Meningeal	1	1	1	0
Trauma	3	1	1	2
Maximum follow-up	6-38 mo.	4-16 mo.	2-48 mo.	3-46 mo.
Duration symptoms first visit	5 days-5 mo.	3 days-1 mo.	2 wk.-1 mo.	1 day-2 mo.

* Of 4 cases described, 2M, 2F.

TABLE II: NONSPECIFIC SPONDYLITIS OF INFANCY AND CHILDHOOD

Series	Fever	Leukocytosis	Elevated Sedimentation Rate	Positive Tuberculin Skin Test
Saenger	2 of 4	2 of 4	2 of 4	none
Bremner & Neligan	6 of 7	not given	not given	none
Dupont & Andersen	3 of 4	2 of 4	3 of 4	2 of 4 (BCG vaccinated)
UCLA	2 of 6	1 of 6	4 of 6	none

a higher incidence in the male (21). The age spread was increased in the current series, with 2 infants of seven months. The initial symptom complex varied among the four major syndromes; only 3 of the 14 cases reported by Saenger, Dupont and Andersen, and the authors of this paper clearly presented with back pain. The hip-leg syndrome was the most common, occurring in 6 of the 14 patients.

Trauma was mentioned in the history of 6 patients of the three groups. It is often noted as preceding various disorders of childhood and infancy and may only mirror the fact that infants and children live dangerously. Two of the 6 patients in the present series gave such a history. In 1, the trauma occurred only three days before entry, obviously after the onset of the spondylitis as judged from the status of the radiographic changes at the time of the first visit. In the other, the trauma had taken place two months before the first examination and one month prior to the onset of symptoms, a more reason-

able sequence for a potential relationship.

The duration of symptoms or observed signs prior to the first examination tended to lie between the usually protracted period of many months characteristic of tuberculous spondylitis and the few days of the explosive form of acute pyogenic spondylitis. However, among the 14 patients there were 2 with a moderately prolonged onset of five and two months, respectively. Several had brief periods of symptoms—one or two days—but without the high fever and prostration characteristic of classical acute hematogenous spondylitis.

Table II points up the lack of signs of systemic infection in roughly half of the 14 patients. Tuberculin skin tests were uniformly negative except in the 2 children previously vaccinated with BCG. Not tabulated are the negative febrile agglutinin tests in all cases and various other skin tests, including those for histoplasmosis, coccidioidosis, and blastomycosis, performed in many patients and always negative. Neither are the mucopolysaccharide and antistreptolysin O titers listed.

Blood cultures were negative in all of our cases and in 1 patient (M. M.), a culture of material obtained at open biopsy of the spinal lesion also proved negative.

In 2 of Saenger's cases blood cultures were reported, both negative. Only 1 of Dupont and Andersen's group had a blood culture, from which *Staphylococcus albus* was grown. In 1 other case of these latter authors an elevated *Staphylococcus* antitoxin titer was reported during the course of the illness. This was their only case with an associated paravertebral abscess. Bremner and Neligan made no such comment concerning blood cultures.

Positive radiographic findings were present on initial examination in all of the currently reported series, as well as in all of the cases of the previously recorded groups. The initial finding was a decrease in height of an intervertebral disk space. If a paravertebral soft-tissue abscess was present (2 of the UCLA and 1 of Dupont and Andersen's cases), it was recognized on initial examination. Progression to vagueness of definition of the opposing vertebral body margins and subsequent irregularity of the same regions was the rule. The appearance of dense bone next occurred, and, much later, the disk space appeared to be increased in height, although it never returned to its original dimension.

Table III indicates, after exclusion of 2 cases with an unusually long onset, relative agreement between the four reported series, as to the average time sequence of events. Time from onset to first visit, to positive radiographic findings, and to diagnosis is essentially the same, since radiographic changes were present at the first visit and since diagnosis was dependent on these findings. This time averaged two and one half to three weeks. The period from onset of symptoms to cessation of all symptoms or clinical recovery is of necessity not clearly delineated in all cases because of the use of immobilization devices, blunting or obscuring the end-point of the illness. This period, however, ranged from nine to thirteen weeks among the four groups.

TABLE III: NONSPECIFIC SPONDYLITIS OF INFANCY AND CHILDHOOD: TIME SEQUENCE OF EVENTS

	Average Time from Onset of Signs or Symptoms to:			
	Disk Space Narrowing (wk.)	Sclerosis (wk.)	Symptom-to-relief (wk.)	Disk Space "Widening" (mo.)
Saenger	3	14	9	7 1/2
Bremner & Neligan	2 1/2	10	13	not given
Dupont & Andersen	3		9	
UCLA series	3	4	9	4 1/2

These values are in marked contrast to tuberculous spondylitis but agree with reports of pyogenic spondylitis.

There was a tendency for the irregularity of the opposing vertebral margins to become worse even though the given infant or child had become asymptomatic, yielding the impression that the radiographic changes progressed while clinically the dis-

TABLE IV: NONSPECIFIC SPONDYLITIS OF INFANCY AND CHILDHOOD: TREATMENT

Series	No. of Cases	Antibiotics Used	Immobilization Used
Saenger	4	2	4
Bremner & Neligan	7	1	7
Dupont & Andersen	4	3	
UCLA Series	6	0	1

ease regressed. It may well be that the progressive irregularity seen is actually a manifestation of healing. The apparent widening of the disk space seen some months later may be a sign of remodeling of the "skirts" of the affected vertebral bodies by bone growth, thus exposing some of the intervertebral disk previously sunk into the softened vertebral bodies.

Table IV lists the treatment employed in the four series.

CASE REPORTS

CASE I: M. M., a white male two and a half years old, had an eighteen-hour history of *abdominal* discomfort. Three days earlier he had fallen in the prone position from a swing. The abdomen was distended and tympanitic. Bowel sounds were normal. Chest and abdominal roentgenograms were erroneously interpreted as normal except for distended loops of small and large bowel. The blood count, urinalysis, and temperature were normal. A rectal tube was inserted, and the child was dis-

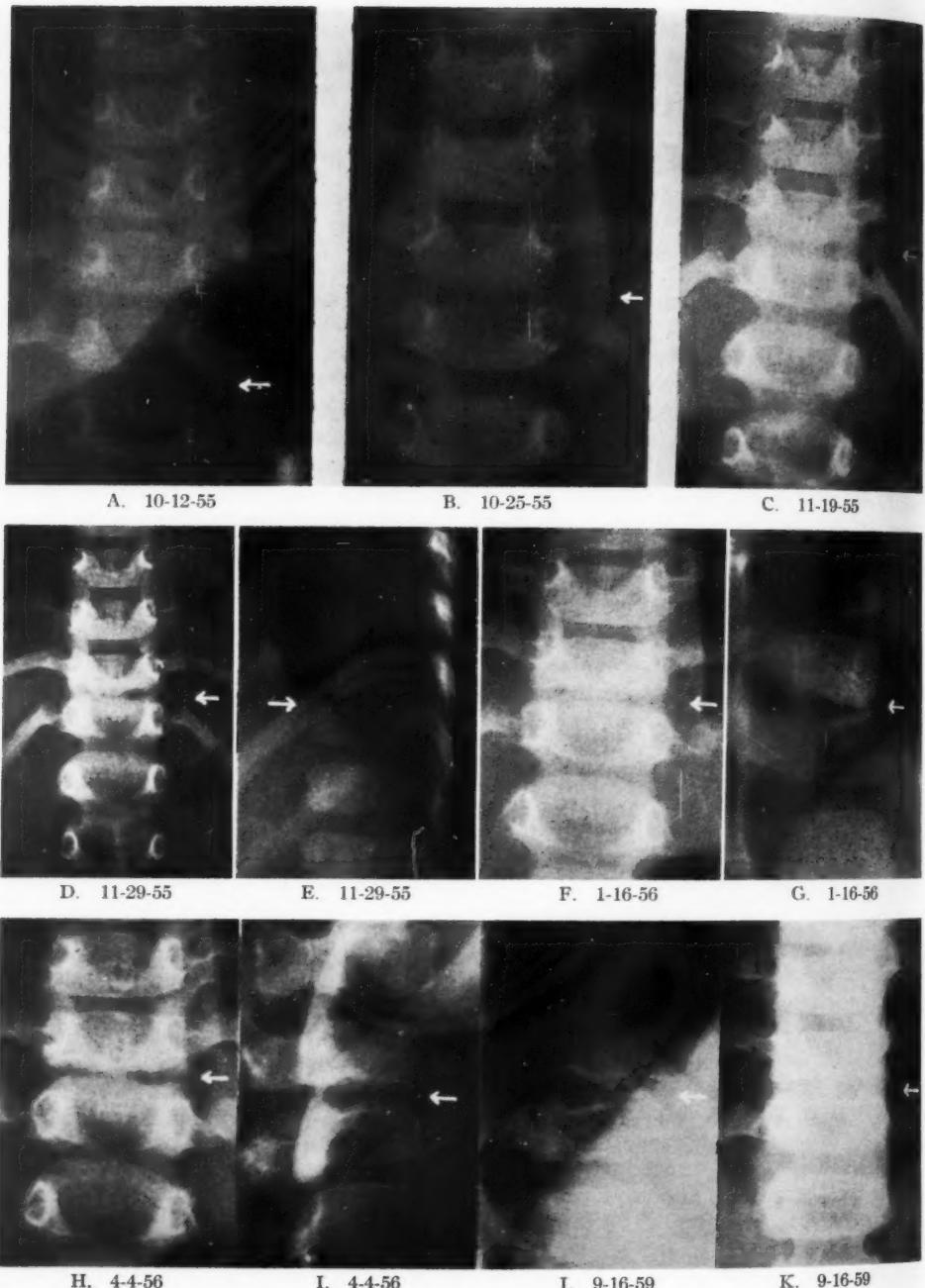


Fig. 1. Case I. M. M., male, age two and a half. Note paravertebral abscess in the earliest view (10-12-55). Disk space narrowing may be present but is certainly not striking.

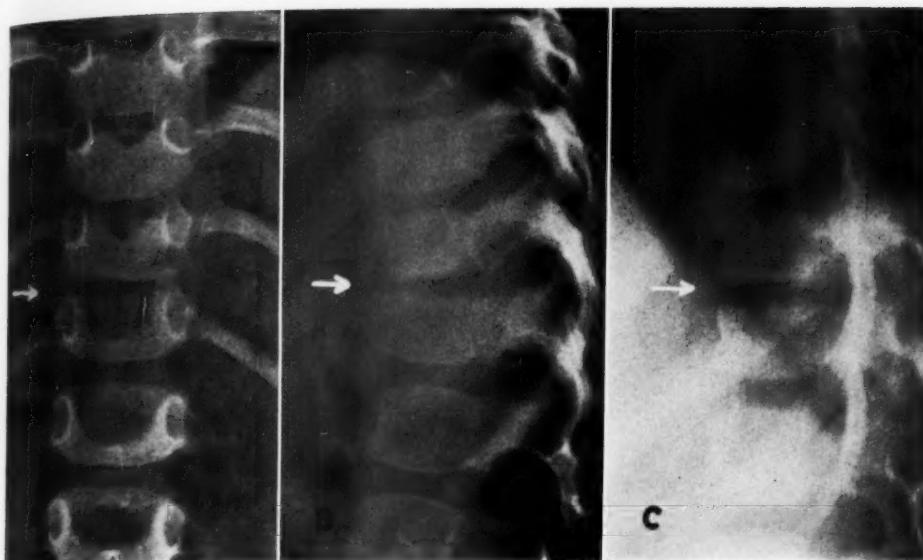


Fig. 2. Case II. B. S., female, age two and a half years. A and B. Initial changes, Dec. 4, 1957, one month from onset. C. Film obtained Jan. 2, 1958.

charged, asymptomatic, two days later, with a diagnosis of gastroenteritis.

Two weeks later he was readmitted because of irritability, anorexia, intermittent crying out, and frequent passing of flatus. The findings were the same as on the initial admission. A supine film of the abdomen, an upper gastrointestinal series, and a barium-enema examination were all erroneously interpreted as normal. The blood count was normal except for a white cell count of 3,700 (normal differential). The tuberculin skin test, febrile agglutinin tests, and liver function tests were all normal or negative. Improvement occurred with bed rest, and the patient was discharged on the third hospital day. The diagnosis was again gastroenteritis.

On readmission two weeks later the prior symptoms and findings had recurred. In addition, there was now refusal to bear weight on the left leg or to sleep on the stomach. Passive motion of the back elicited pain. An intravenous urogram resulted in observation of a narrowing of the D11-D12 disk space, irregularity of the opposing vertebral margins, and paraspinal soft-tissue density. Skin tests for tuberculosis, coccidioidosis, histoplasmosis, and blastomycosis were negative. The sedimentation rate was 31 mm. in an hour. A needle aspiration of the affected interspace was done and examination, including cultures of the spinal fluid, was negative. Open biopsy revealed only nonspecific inflammatory tissue. All cultures of this material were negative.

Six weeks after onset of the disease, the radiographic findings were clear-cut. There were slight

gibbus, marked anterior loss of disk space, and beginning sclerosis of the irregular opposing vertebral body margins. The patient was entirely asymptomatic at this time. Additional roentgen studies three months after onset of disease indicated a slight widening of the disk space. Films about two years after onset showed the interspace to be permanently narrowed, with mild irregularity of the opposing vertebral margins.

Comment: This child had three hospital admissions and many diagnostic tests. There was no fever or other sign of systemic infection. No antibiotics were used. Changes were present on the initial roentgenograms that might have suggested the diagnosis but were not detected. The only treatment was the bed rest incidental to the diagnostic studies. Some restoration or repair took place at the involved level in the spine, but residual disk space narrowing and vertebral "plate" irregularity were present almost four years later. The symptoms permanently disappeared six weeks after onset.

CASE II: B. S., a white female, two and a half years old, was admitted to the service of Dr. H. O. Mosier. For one month she had experienced initially ill defined *abdominal* discomfort and anorexia. At the time of admission the lumbar curve was seen to be straightened, and the child walked with

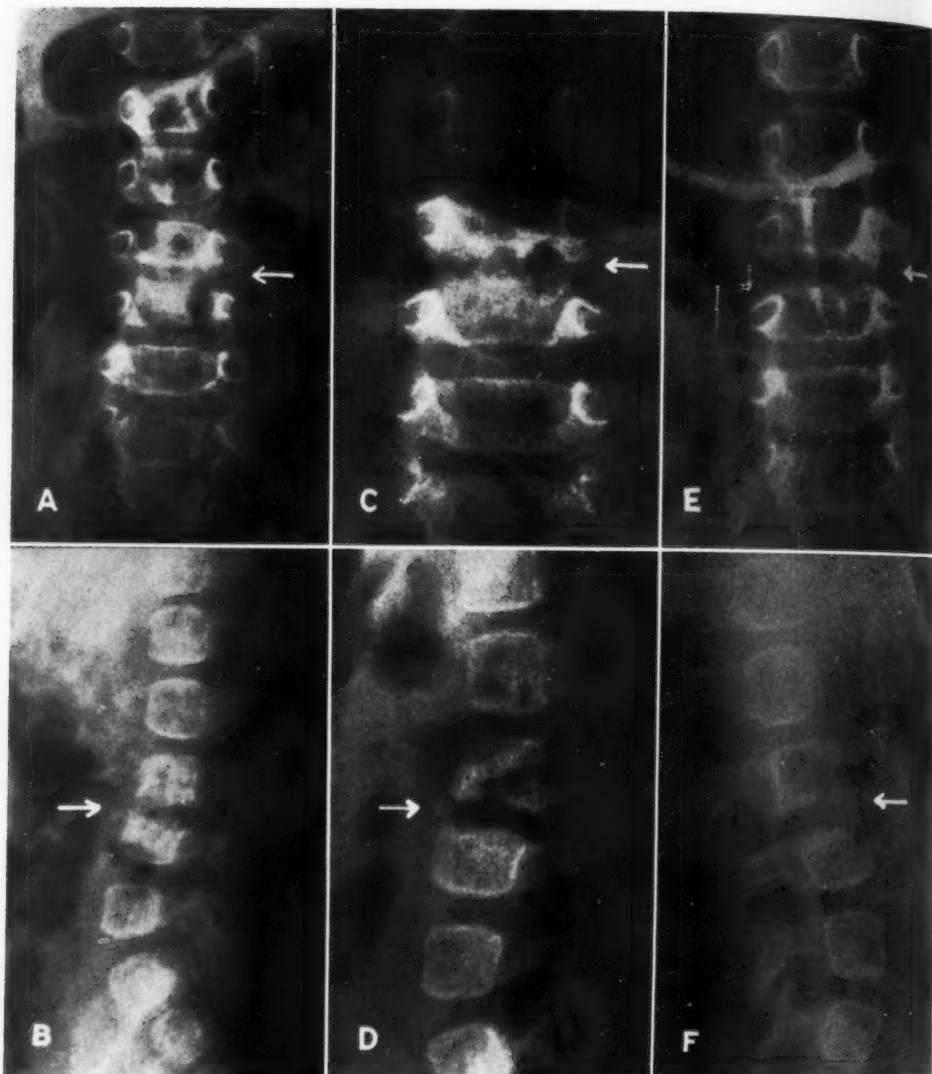


Fig. 3. Case III. V. J., female, age seven and a half months. Changes are late in course (five and a half weeks from onset). Films A and B obtained Sept. 22, 1959; C and D, Dec. 4, 1959; E and F, Feb. 5, 1960.

the knees bent. Two months prior to the onset she had fallen on her back. Films of the spine made just prior to referral indicated narrowing of the D11-D12 interspace and irregular sclerotic opposing vertebral body margins. Fever was not documented prior to entry or during the period of study.

The patient was reluctant to move about and preferred to lie still on her back, which was held straight in the sitting or standing posture. When she stood, the knees were slightly flexed. There was no point tenderness over the spine. The urinalysis

and complete blood count were normal. The corrected Westergren sedimentation rate was 38 mm. in an hour. Venereal disease and febrile agglutinin tests were negative, as was the anti-streptolysin O titer. The seromucoid was 4.8 mg. per cent. Skin tests for tuberculosis, histoplasmosis, and coccidioidosis were negative and 8 blood cultures at two-hour intervals showed no growth. Roentgenograms of the spine about two months from onset were not discernibly different from those obtained one month previously. The child was placed in a bivalved body cast for seven

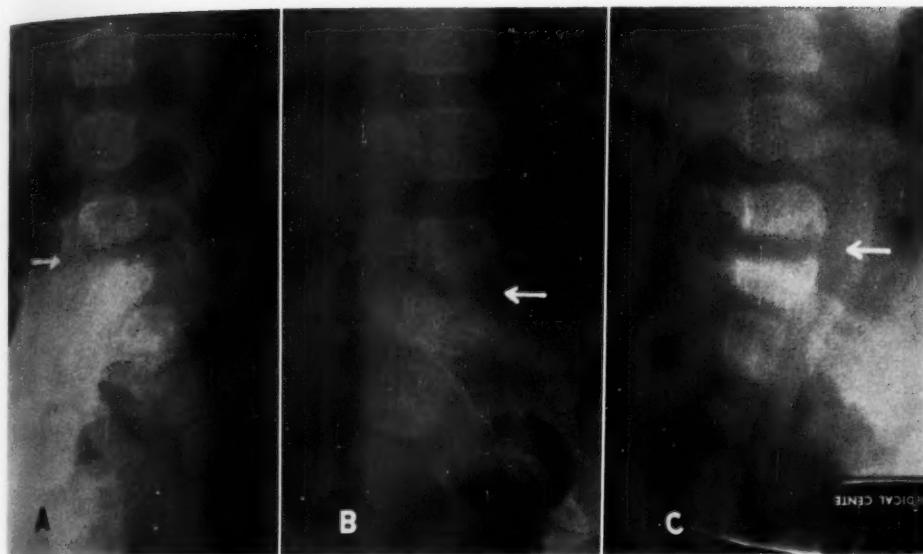


Fig. 4. Case IV. J. A., seven-month-old male. The changes are well advanced and include sclerosis (C), approximately four months from onset. Films obtained Sept. 25, 1959 (A); Oct. 1, 1959 (B); Dec. 28, 1959 (C).

months and it was not possible to evaluate the time of symptomatic recovery. She was without question symptom-free when the cast was removed, at which time the sedimentation rate was normal.

Comment: This was the second case encountered and again the diagnostic tests were numerous. No antibiotics were employed.

CASE III: V. J., a white female seven and a half months old, was seen with a five-week history of irritability, nocturnal restlessness, apparent discomfort in the sitting or prone position, and no documented fever. She was unwilling to stand with support and held the right thigh in partial flexion. There was straightening of the back. Roentgenograms showed a narrowed L3-L4 disk space anteriorly and striking irregularity and increased density (sclerosis) of the respective opposing vertebral margins. Urinalysis, a blood count, and the sedimentation rate were normal. Skin tests for tuberculosis, histoplasmosis, and coccidioidosis were negative, as were febrile antigen tests. The child was still irritable when roentgenograms were made twelve days after the initial examination and again about seven weeks after onset of the disease. At this time there were some widening of the interspace and increased sclerosis and there appeared to be beginning smoothing of the ragged vertebral plates. The patient was completely asymptomatic twelve weeks after onset, when films indicated further widening of the interspace and, possibly, added sclerosis. Treatment was entirely

expectant, on an outpatient basis, and consisted mainly of diminished handling.

Comment: This was our third case. Management was conservative; there was no recorded fever; no antibiotics were used.

CASE IV: J. A., a seven-month-old white male, was seen after three weeks of irritability, progressing to decreased activity, dislike of being handled, and refusal to sit or stand with support. There was a daily rise of temperature to 104° F. for the four days prior to entry, but the child was afebrile at the first examination and remained so thereafter. There was full range of passive motion of all the extremities and no apparent elicitation of pain on passive flexion of the spine. Spinal roentgenograms showed L5-S1 interspace narrowing with irregularity of the opposing vertebral margins and increased opacity of the adjacent margin of the first sacral centrum. The initial white blood count was 19,380, with no shift, but 7 per cent eosinophils. The sedimentation rate was 34 mm. in an hour. Spinal fluid examination, the usual skin and agglutination tests, and the antistreptolysin O titer were all negative. A repeat white blood count one week after entry was 5,850, with 8 per cent eosinophils; the sedimentation rate was normal. At this time the baby was more active, would sit without crying but still refused to stand with support. Recheck films of the spine revealed only slight additional irregularity of the vertebral plates. The child was discharged for outpatient follow-up. Spinal

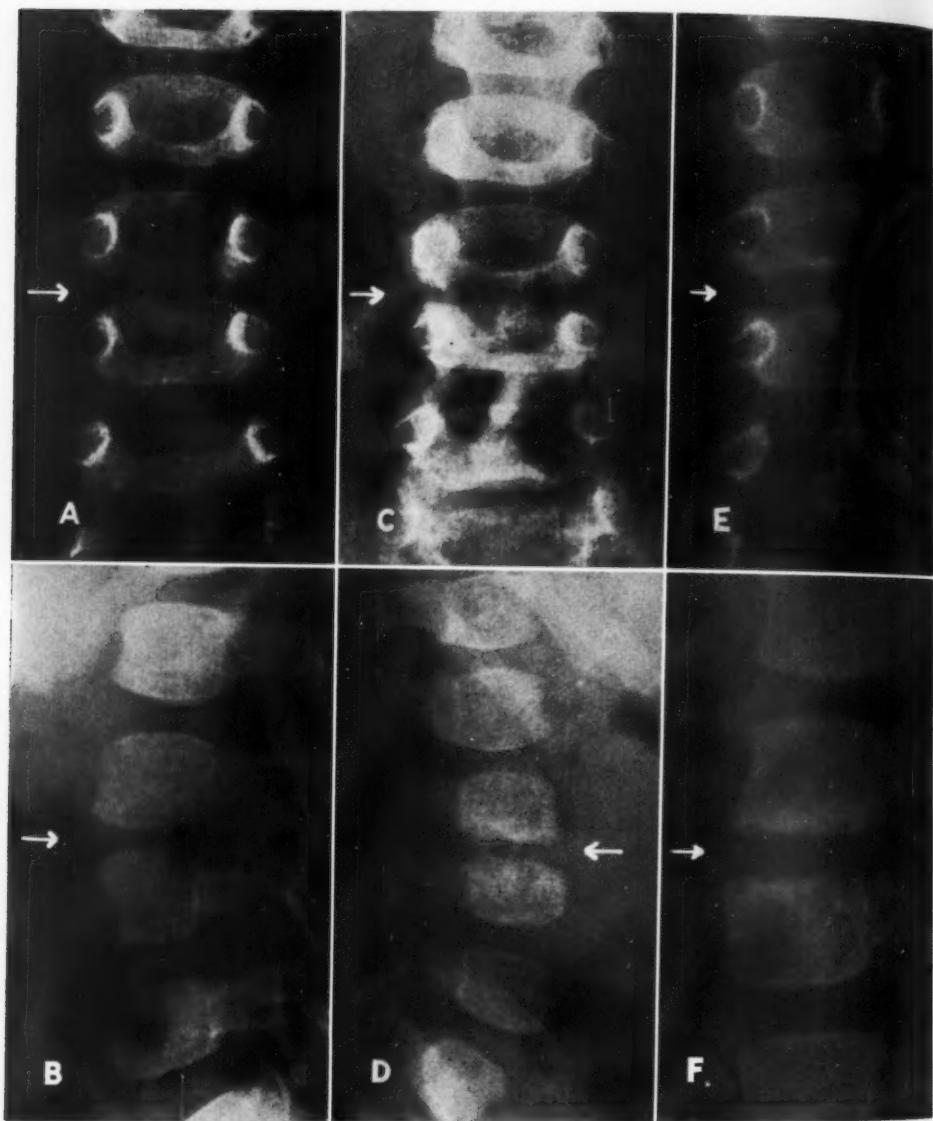


Fig. 5. Case V. R. S., female fifteen months old. Initial films, A and B, Oct. 2, 1959; two months from onset C and D, Nov. 23, 1959; E and F at last examination, May 17, 1960, clearly show disk space widening.

roentgenograms obtained about four months after the onset indicated some smoothing of the ragged vertebral margins and additional sclerosis. Symptoms were now completely absent.

Comment: Management in this case was again conservative, with antibiotics.

CASE V: R. S., a fifteen-month-old white female, was admitted to the service of Dr. H. Grossman, with an illness which apparently began with fever,

upper respiratory symptoms, and diarrhea two months earlier. The diarrhea and upper respiratory symptoms were brief in duration, but the fever, up to 103° F., had persisted off and on for the two months. The child cried out at times as though in pain, exhibited buckling of the left leg on attempted walking, and eventually refused even to sit up. She was febrile on entry, and physical examination revealed only decreased spontaneous movement of the left leg. There was full range of

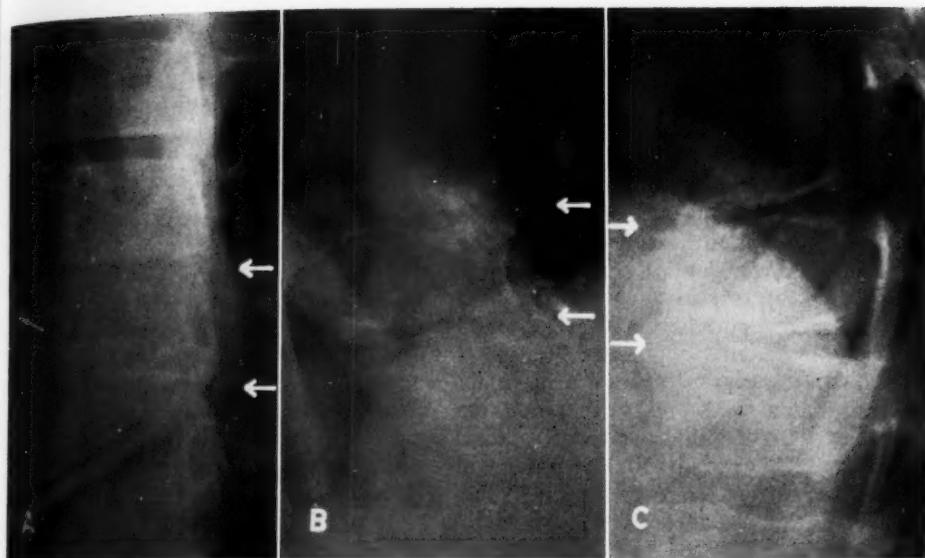


Fig. 6. Case VI. D. H., 13-year-old male. Note paravertebral soft-tissue abscess and involvement of two interspaces and three vertebral bodies. A and B, obtained Oct. 29, 1959; C, Nov. 16, 1959.

passive motion of both legs and no apparent spinal tenderness. The white blood count was normal but the sedimentation rate was 37 mm. in an hour (corrected Wintrobe). Urinalysis was also normal except for a trace of albumin. The usual skin tests and febrile agglutination tests were negative, as was the antistreptolysin O titer. The seromucoid was 6.3 mg. per cent.

The initial films of the lumbar spine indicated narrowing of the L3-L4 interspace, with barely detectable unsharpness of the posterior portions of the opposing vertebral margins. No sclerosis was present. In five days the child was much more active and was discharged. Recheck films made four months after onset and eight weeks after hospital entry indicated progression of the changes, demonstrating marked irregularity of the opposing vertebral margins and sclerosis. Films nine months after onset showed widening of the interspace, smoothing of the vertebral margins, and additional sclerotic change. The child became asymptomatic shortly after her discharge from the hospital.

Comment: Treatment was conservative and no antibiotics were used.

CASE VI (courtesy of Dr. R. B. Portis): D. H., a thirteen-year-old white male, had for five days suffered mid backache on first getting out of bed, recurring if he engaged in running, jumping, or bending. An earache of brief duration had occurred three weeks prior to onset of the backache. There was acute tenderness over D11 and pain in that region was elicited by thigh flexion. Roent-

genograms of the spine (courtesy of Dr. L. G. Riger) demonstrated marked narrowing of the D10-D11 interspace with sclerotic irregular opposing vertebral margins. In addition, lesser similar changes were evident at the D11-D12 interspace. Furthermore, an increased density of the paravertebral soft tissues embracing these areas was present. The patient was apparently afebrile. The day after the first examination he complained of pain in the region of the left hip and there was tenderness to deep palpation over the femoral head. This persisted as the chief complaint for two and a half weeks, gradually decreasing.

Brucellin, coccidioidin, and tuberculin skin tests were all negative. The patient was asymptomatic, except for minimal discomfort in the left hip after running, when the next recheck films were made a little under three weeks from the onset of the disease. These indicated no change except minimal increase in the sclerosis. Films two and a half months after onset appeared the same as those obtained at the prior examination.

Comment: Treatment consisted in reduced activity. No antibiotics were used.

DISCUSSION

Spondylitis or vertebral inflammation is, by popular usage, roughly divisible into two categories: (a) rheumatoid spondylitis, (b) specific infectious spondylitis. The latter may be further divided (a) into

tuberculous and nontuberculous infections of the spine or, alternatively, (b) into hematogenous vertebral osteomyelitis, inclusive of both tuberculous and nontuberculous spondylitis, and spondylitis due to direct inoculation (iatrogenic).

Spinal location of osteomyelitis, whatever the etiologic agent, is not common. Among 2,000 patients referred for obscure back pain, Ghormley (6) found 38 with tuberculous spondylitis and 5 with nontuberculous spondylitis. Winters and Cahen (24) recently reported 66 cases of acute hematogenous osteomyelitis accumulated in three and one-third years. In only 1 was the location vertebral. Morse and Pyles (12) noted spinal involvement in only 1 of 67 cases of bone and joint infection in patients under thirteen years of age, collected in a fourteen-year period. Wiley and Trueta (23), also in a fourteen-year period, found 19 cases of vertebral osteomyelitis among 202 instances of osteomyelitis. Harris (8) reported 45 examples of acute osteomyelitis, collected during seven years, in 2 of which there was vertebral involvement. Clarke (3) recorded 24 cases of osteomyelitis in the neonatal period, in 3 of which the vertebrae were involved.

From an etiologic standpoint it would appear that spondylitis due to the tubercle bacillus must still be more common than that due to all other organisms (18). Reports indicate that the *Staphylococcus* was and continues to be the commonest cause of nontuberculous spondylitis. It is said that this organism causes about 80 per cent of pyogenic vertebral osteomyelitis (13). In areas where brucellosis remains endemic, spondylitis due to one of this family of organisms is relatively frequent. Zammit (25) reported 62 cases of vertebral involvement seen over a seven-year period on the island of Malta. It is interesting to note that, whereas the age incidence of brucellosis during this period on Malta was relatively even by decades, the peak incidence of spondylitis was in the fourth through the sixth decades. These 62 instances of spondylitis occurred against a

backdrop of 6,000 reported cases of brucellosis.

At this point it might be well to examine briefly the basis for assigning a specific infectious etiology to bone infection in general and vertebral infection in particular. As a rule, osteomyelitis of the long bones provides more frequent access to pus for culture either because of soft-tissue fluctuations, surgical intervention, or associated joint spread, permitting needle aspiration. Thus, more or less direct proof from cultures of the exudate at the site of infection is obtained in the case of long-bone involvement. On the other hand, vertebral infection often has a specific etiology assigned by inference. In the case of that due to tuberculosis, a positive skin test, present or past proved tuberculosis of the lung, urinary tract, or other soft-tissue part, or a so-called cold abscess in the costovertebral angle or groin may provide the background for the inference. In the case of tuberculosis, slow progression of the changes over many months, with relatively marked destructive change eventuating in severe deformity, is taken as confirmatory evidence. In nontuberculous spondylitis, a positive blood culture, recent presence of known or inferred pyogenic infection such as otitis, pharyngitis, or furunculosis, previous or current urinary tract infection, recent laminectomy or spinal puncture, or recent systemic infection such as typhoid fever or brucellosis may pave the way for an inferential linkage between the discovered changes in the spine and the prior infection or surgical procedure. More rapid progression of the changes observed radiographically tends to suggest a nontuberculous or pyogenic etiology. A reluctance to risk spread of infection to the spinal subarachnoid space by scalpel or needle techniques for diagnostic purposes inhibits the development of bacteriologic proof ordinarily obtained in bone infection elsewhere.

In 1931, Doub and Badgley (4) reported 3 cases of what they called tuberculosis of the intervertebral articulations. They proposed this term because the chief radio-

graphic feature was a narrowing of the intervertebral disk space with but slight alteration in the contiguous surfaces of the two vertebral bodies. They pointed out that the roentgen changes did not progress to the severe destruction usually seen in tuberculous spondylitis. Two of these cases were assigned a tuberculous etiology on the basis of death of guinea-pigs inoculated with pus from silent or "cold" costovertebral abscesses. The third patient was believed to have a tuberculous spondylitis because of a history of pleurisy with effusion one year before. These authors mentioned that, although healing tended to occur without progression to severe destruction, in none of the 3 cases was dense bone laid down in the healing or late follow-up phase.

Ghormley, Bickel, and Dickson (7), in 1940, reported what they called "acute infectious lesions of the intervertebral disks" in 20 patients. In all, the principal finding was narrowing of the intervertebral disk space, with minimal evidence of bone destruction affecting the contiguous surfaces of the concerned vertebral bodies. Thirteen patients were sufficiently ill to be confined to bed. Apparently no specific etiology could be proved although 12 had a recent antecedent infection elsewhere in the body. Ghormley *et al.* pointed out that the radiographic changes pursued a course in no wise different from the various pyogenic forms of spondylitis of milder degree, those produced by typhoid and brucellosis organisms, and the milder forms of tuberculous spondylitis alluded to above, with the exception that in their cases sclerosis of the affected vertebral margins developed in the healing stage, in contrast to tuberculous spondylitis.

This tendency to separate out the type of spondylitis marked by disk space narrowing and minimal bone changes continues with a recent report by Scherbel and Gardner (17) on infections involving the intervertebral disks. They had 10 patients with back pain and radiographically demonstrable disk space narrowing, followed by irregular destruction of con-

tiguous portions of the vertebral bodies, and, finally, by varying degrees of sclerosis of the adjacent vertebral margins, some with late fusion. In 5 cases, the changes followed shortly after diagnostic or therapeutic procedures in relation to the spine, and in 5 they were related by the authors to preceding urinary tract infections. Vigorous diagnostic effort led to proof of infection either by aspiration or curettage of the intervertebral disk in 7 of the 10 cases with positive culture in each of these. Kelly, Martin, Schirger, and Weed (10), in analyzing 36 cases of brucellosis of the bones and joints, found that 17 involved the spine, but of these 17, only 3 yielded positive cultures, the remainder being "proved" by increased agglutination titers (1:800 or higher). It should be noted that the radiographic changes were the same as those cited above.

In considering the background into which the present series of cases must be fitted, certain trends are of interest. Streptococcal osteomyelitis of infancy and childhood was once common (12, 24, 8, 3). Neonatal osteomyelitis may present few systemic signs of infection (3). It is interesting that in Clarke's series the local signs were so subdued that the 3 cases of vertebral involvement were discovered only after large retroperitoneal abscesses formed and the mandibular cases were recognized only after the sinuses drained into the mouth. Janeway (9) attributed the differences between neonatal and adult infectious manifestations to a lack of specific hypersensitivity to a first infection. In reading case reports of osteomyelitis in infancy and early childhood it is not uncommon to find that fever is entirely absent and the diagnosis is delayed. Thus there is a small group of cases in which antibiotics were not employed, apparently without any dire consequences.

In this light, it would seem that the 6 cases reported here, as well as those of Saenger, Bremner and Neligan, and DuPont and Andersen, probably represent a new entity from an etiologic standpoint. They may possibly, however, be instances

of pyogenic spondylitis of milder form and course. Certainly, the radiographic changes and the time sequence were little different from those of proved pyogenic spondylitis.

Differential diagnosis would not seem difficult once either disk space narrowing or the presence of a soft-tissue abscess is recognized. It is largely one of separating out three possibilities: (a) tuberculous spondylitis, (b) pyogenic spondylitis, and (c) nonspecific spondylitis. In the first instance, the usual experience is to have a history of a prior tuberculous infection; persistent signs and symptoms of spinal involvement on examination, without initial detection of radiographic changes; a positive tuberculin skin test. Later there is advanced destructive change in the affected vertebrae without evidence of reactive new bone or sclerosis. Pyogenic spondylitis, on the other hand, is likely to be preceded by pyogenic infection elsewhere or by spinal surgery, lumbar puncture, aortography, or other form of paravertebral injection; it tends to be accompanied by systemic signs of infection; and it often has positive radiographic findings at initial examination. Evolution of the changes is rapid as compared with tuberculous spondylitis and destruction is seldom as severe as with tuberculous infection. Nonspecific spondylitis becomes the diagnosis of choice when reasonable efforts to assign a specific etiology fail. Unduly prolonged or traumatic diagnostic procedures seem unwarranted in view of the favorable prognosis with conservative management.

Two other conditions that may be mentioned seem to offer little in the way of differential difficulty. Localized Scheuermann's disease affecting but one or two vertebral bodies may produce bone-destructive change but not disk space narrowing (2). Rheumatoid spondylitis granuloma (22) and eosinophilic granuloma may cause considerable destruction in the affected vertebral bodies but do not narrow the disk space. Changes elsewhere in the spine should lead to proper evaluation.

SUMMARY

We have presented 6 cases of a self-limited benign form of spondylitis. The radiographic changes consist of paravertebral swelling, initial disk space narrowing, followed shortly by destructive change at the opposing vertebral margins, and, finally, evidence of the arrest of the process with the appearance of reparative new bone. Late follow-up usually indicates persistent narrowing of the affected disk space although some partial restitution may occur.

The patients in this group all recovered spontaneously without the employment of antibiotic therapy. The average time from onset of symptoms to detection of radiographic changes was three weeks, and from onset to subsidence of symptoms, nine weeks. This agrees well with two previously reported similar series. These cases all occurred in children and involved the sexes equally.

It is not clear at this time whether these cases represent a new etiologic group or are merely variants of infectious spondylitis.

NOTE: Since this paper was submitted for publication, two additional series have been published with similar findings:

1. DOYLE, J. R.: Narrowing of the Intervertebral Disc Space in Children, Presumably an Infectious Lesion of the Disc. *J. Bone & Joint Surg.* **42-A:** 1191-1200, October 1960.

2. CHILDE, A. E., AND TUCKER, F. R.: Spondylarthritis in Infants and Children. *J. Canad. A. Radiologists* **12:** 47-51, June 1961.

University of California Medical Center
Los Angeles 24, Calif.

REFERENCES

1. BRENNER, A. E., AND NELIGAN, G. A.: Benign Form of Acute Osteitis of the Spine in Young Children. *Brit. M. J. 1:* 856-860, April 18, 1953.
2. BROWN, N. M.: Localized Osteochondritis of the Spine. *J. Canad. A. Radiologists* **9:** 26-31, June 1958.
3. CLARKE, A. M.: Neonatal Osteomyelitis: A Disease Different from Osteomyelitis of Older Children. *M. J. Australia* **1:** 237-239, Feb. 22, 1958.
4. DOUB, H. P., AND BADGLEY, C. E.: Tuberculosis of Intervertebral Articulations. *Am. J. Roentgenol.* **25:** 299-306, March 1931.
5. DUPONT, A., AND ANDERSEN, H.: Non-Specific Spondylitis in Childhood. *Acta paediat.* **45:** 361-366, July 1956.
6. GHORMLEY, R. K.: An Etiologic Study of Back Pain. *Radiology* **70:** 649-652, May 1958.

7. GHORMLEY, R. K., BICKEL, W. H., AND DICKSON, D. D.: Study of Acute Infectious Lesions of Intervertebral Discs. *South. M. J.* **33**: 347-353, April 1940.
8. HARRIS, N. H.: Some Problems in the Diagnosis and Treatment of Acute Osteomyelitis. *J. Bone & Joint Surg.* **42-B**: 535-541, August 1960.
9. JANEWAY, C. A.: Infectious Disease and Immunity in Early Life. *Pediat. Clin. North America* **7**: 79-812, November 1960.
10. KELLY, P. J., MARTIN, W. J., SCHIRGER, A., AND WEED, L. A.: Brucellosis of the Bones and Joints: Experience With Thirty-Six Patients. *J.A.M.A.* **174**: 347-353, Sept. 24, 1960.
11. LEWIS, O. J.: The Blood Supply of Developing Long Bones with Special Reference to Metaphyses. *J. Bone & Joint Surg.* **38-B**: 928-933, November 1956.
12. MORSE, T. S., AND PRYLES, C. V.: Infections of Bones and Joints in Children. *New England J. Med.* **262**: 846-852, April 28, 1960.
13. NASSIM, R., AND BURROWS, H. J.: Modern Trends in Diseases of the Vertebral Column. New York: Paul B. Hoeber, Inc., 1959.
14. PRITCHARD, A. E., AND THOMPSON, W. A. L.: Acute Pyogenic Infections of the Spine in Children. *J. Bone & Joint Surg.* **42-B**: 86-89, February 1960.
15. RICHARDS, A. J.: Non-Tuberculous Pyogenic Osteomyelitis of the Spine. *J. Canad. A. Radiologists* **11**: 45-49, September 1960.
16. SAENGER, E. L.: Spondylarthritis in Children. *Am. J. Roentgenol.* **64**: 20-29, July 1950.
17. SCHERBEL, A. L., AND GARDNER, W. J.: Infections Involving the Intervertebral Disks; Diagnosis and Management. *J.A.M.A.* **174**: 370-374, Sept. 24, 1960.
18. SCHMORL, G., AND JUNGHANNS, H.: The Human Spine in Health and Disease. New York, Grune & Stratton, 1959.
19. TRUETA, J.: The Three Types of Acute Haemogenous Osteomyelitis: A Clinical and Vascular Study. *J. Bone & Joint Surg.* **41-B**: 671-680, November 1959.
20. TRUETA, J., AND AMATO, V. P.: The Vascular Contribution to Osteogenesis. 3. Changes in the Growth Cartilage Caused by Experimentally Induced Ischaemia. *J. Bone & Joint Surg.* **42-B**: 571-587, August 1960.
21. WEAR, J. E., BAYLIN, G. J., AND MARTIN, T. L.: Pyogenic Osteomyelitis of the Spine. *Am. J. Roentgenol.* **67**: 90-94, January 1952.
22. WHOLEY, M. H., PUGH, D. G., AND BICKEL, W. H.: Localized Destructive Lesions in Rheumatoid Spondylitis. *Radiology* **74**: 54-56, January 1960.
23. WILEY, A. M., AND TRUETA, J.: The Vascular Anatomy of the Spine and Its Relationship to Pyogenic Vertebral Osteomyelitis. *J. Bone & Joint Surg.* **41-B**: 796-809, November 1959.
24. WINTERS, J. L., AND CAHAN, I.: Acute Hemogenous Osteomyelitis. A Review of 66 Cases. *J. Bone & Joint Surg.* **42-A**: 691-704, June 1960.
25. ZAMMIT, F.: Undulant Fever Spondylitis. *Brit. J. Radiol.* **31**: 683-690, December 1958.

SUMMARIO IN INTERLINGUA

Spondylitis Non-Specific in Infantes e Juveniles

Es presentate 6 casos de un forma benigne e auto-limitante de spondylitis. Le alterationes radiographic consiste de tumescencia paravertebral con restriction initial del discos, sequite prestemente per alterationes destructive al opponite margines vertebral, e—finalmente—evidentia del arresto del processo con le apparition de nove ossos reparatori. Subsequente observationes de controllo indica usualmente un persistente restriction del afficite spatio discal, ben que un restitution partial pote occurrer.

Le patientes in iste serie variava in etates inter septe menses e dece-tres annos e eseva equalmente dividite inter masculos e femininas. Omnes se restabliava spontaneamente sin le uso de therapia anti-

biotic. Le duration medie ab le declaracion de symptomas usque al detection del alterationes radiographic eseva tres septimanas e ab le declaracion usque al subsidencia del symptomas novem septimanas.

Il non es clar a iste tempore si iste casos representa un novo gruppo etiologic o es solmente variantes de spondylitis infectiose. Le desiro de evitar le risco de un dissemination del infection ad le spatio subarachnoide spinal per le uso de scalpello o agulha pro objectivos diagnostic inhibe le disveloppamento de provas bacteriologic del genere ordinariamente obtenite quando un infection occorre in altere partes del sistema ossee. Spondylitis tuberculotic e pyogenic es le major conditions a differentiar.

Osteitis Deformans (Paget's Disease of Bone)

A Morphologic Study Utilizing Microradiography and Conventional Techniques¹

PATRICK J. KELLY, M.D., LOWELL F. A. PETERSON, M.D., DAVID C. DAHLIN, M.D.,
and GEORGE E. PLUM, M.D.

THE roentgenologist and the orthopedist are so familiar with the radiologic picture of osteitis deformans that in most cases the diagnosis is made easily from the film. The purpose of this communication is to review the microscopic

aspects have been described by Schmorl (10), Knaggs (7), and Jaffe (5). The classic morphologic appearance is that "in which tiny fragments of lamellar bone are fitted into one another like a very irregular mosaic with little tendency for

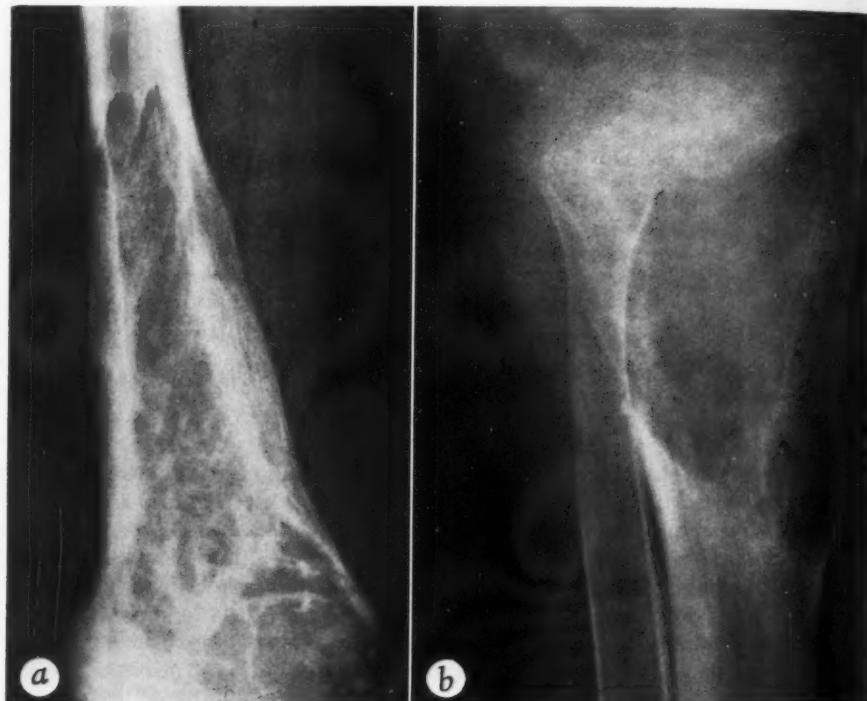


Fig. 1. a. Sclerotic or fully developed osteitis deformans of the distal half of the femur.
b. Porotic osteitis deformans of the proximal tibia.

features of the disease and to correlate the conventional histologic and microradiographic appearances. The few microradiographic studies that have been reported (2, 11) have concerned only fully developed Paget's disease.

Since the original description (1, 8, 12, 13) of osteitis deformans, its histologic

the bone fragments to be arranged about vessels to form haversian systems" (5).

MATERIALS AND METHOD OF STUDY

Fourteen specimens (5 humeri, 6 tibiae, 1 femur, 1 skull, and 1 iliac crest) were available for study. Five specimens (4 humeri and the femur) were removed from

¹ From the Section of Orthopedic Surgery (P. J. K.; L. F. A. P.), the Section of Surgical Pathology (D. C. D.), and the Section of Radiology (G. E. P.), Mayo Clinic and Mayo Foundation, Rochester, Minn. Accepted for publication in February 1961.

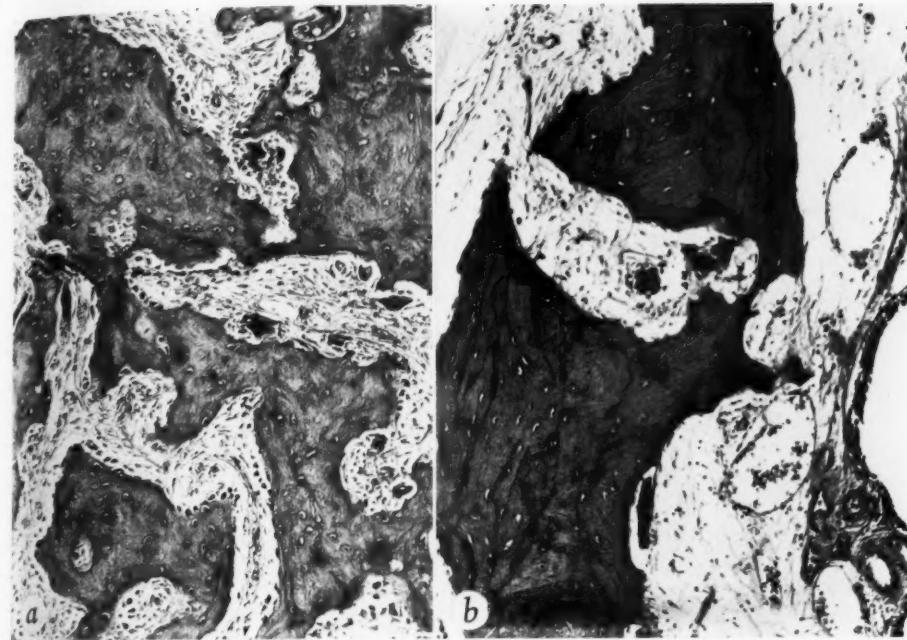


Fig. 2. Fully developed osteitis deformans. *a*. Thickened beams of bone with large spaces filled with vascular connective tissue. Osteoblasts and osteoclasts are prominent along the edges of the bone. Mosaic pattern is not as apparent as in Fig. 2, *b*. (Hematoxylin and eosin. $\times 100$.)

b. Cement lines are demonstrated better in this section than in *a*. The staining with hematoxylin is heavier, and the counterstaining with eosin is much lighter ($\times 100$). Section is from same block as *a*.

amputated limbs in which malignant changes had occurred. In 2 cases specimens of adequate size were obtained at necropsy and the remaining 7 were removed at operation for some complication of osteitis deformans or to rule out malignancy.

Blocks of bone 1×2 cm. were removed from the specimen with a coping saw, and sections were cut from these on a milling machine for microradiography. These sections were 150 micra thick and were further ground by the method of Frost (3) to a thickness of 75 micra or less. Two specimens were embedded in methyl methacrylate so that they could be ground to a thickness of less than 50 micra. Specimens that were to be submitted to microradiography were stored in absolute alcohol to prevent decalcification.

The larger block was marked so that after decalcification in formic acid the prepared histologic specimens could be sectioned in such a way that they would be

separated from the parts examined by microradiography only by the thickness of the saw cut. After decalcification the large block was embedded in paraffin, sectioned, and stained with hematoxylin and eosin. Polarized light was used to study unstained sections; in addition, the sections examined by microradiography were decalcified and then studied under polarized light. The techniques were identical with methods we have reported previously (6).

CLASSIFICATION OF MORPHOLOGIC FINDINGS

For convenience we have classified the morphologic findings into three types.

The first is sclerotic-appearing Paget's disease, called by Jaffe "fully developed osteitis deformans." The roentgenologist recognizes this as the most common type (Fig. 1, *a*).

The second is early or porotic osteitis deformans, usually recognized radiologically as an early form of the disease (10). Jaffe referred to the new osseous trabeculae

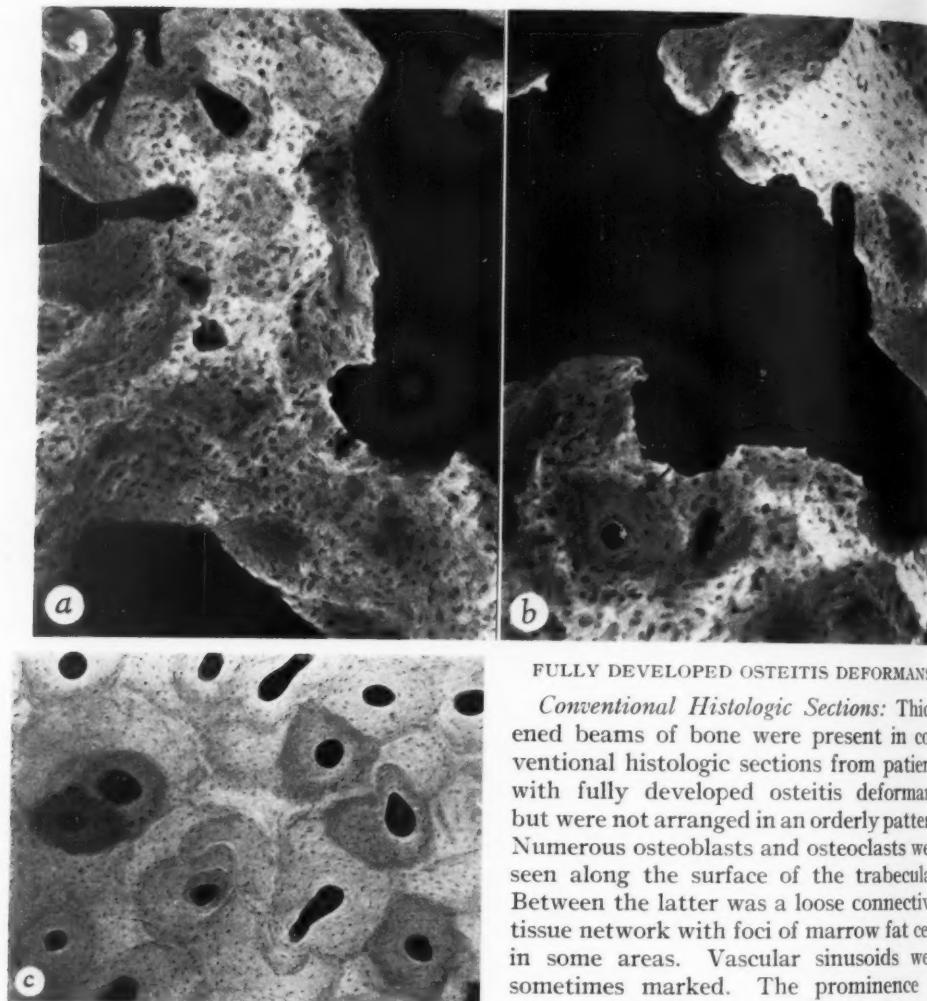


Fig. 3. Microradiographs. *a*. Typical appearance of fully developed osteitis deformans in cortical bone of humerus. Patches of bone with higher mineral (whiter) content lie next to areas of less mineral content (grayer). Normal haversian architecture has been lost (15 kv; 15 ma; 20 min.; $\times 100$).

b. An occasional haversian system may be seen in fully developed osteitis deformans. Arrow indicates haversian system (15 kv; 15 ma; 20 min.; $\times 90$).

c. Normal cortical bone (15 kv; 15 ma; 20 min.; $\times 80$).

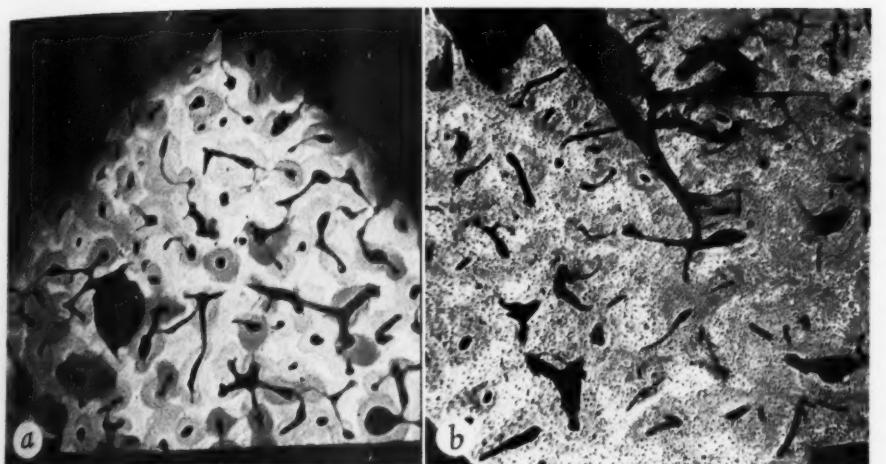
of this type as connective-tissue bone (Fig. 1, *b*).

The third form we prefer to call "pre-sarcomatous osteitis deformans." In our study we have seen this appear in a transitional area between fully developed osteitis deformans and complicating sarcoma.

FULLY DEVELOPED OSTEITIS DEFORMANS

Conventional Histologic Sections: Thickened beams of bone were present in conventional histologic sections from patients with fully developed osteitis deformans, but were not arranged in an orderly pattern. Numerous osteoblasts and osteoclasts were seen along the surface of the trabeculae. Between the latter was a loose connective-tissue network with foci of marrow fat cells in some areas. Vascular sinusoids were sometimes marked. The prominence of the mosaic pattern in the individual beams varied with the staining technic. Staining heavily with hematoxylin and lightly with eosin made the cement lines more discernible and the mosaic more apparent (Fig. 2).

Microradiographs: The microradiographs demonstrated the loss of normal architecture in cortical bone affected by osteitis deformans. Those reproduced in Figure 3, *a* and *b*, are of sections of the typical osteitis deformans illustrated in Figure 2. In the beams of bone are patches of bone of differing mineral content, lying adjacent to each other. By



comparing Figure 3, *a* and *b*, with Figure 3, *c*, one can observe how disturbed the structure of the cortical bone was. Only an occasional complete haversian system can be made out (Fig. 3, *b*).

Study of cortical bone at the margin of an involved region of compact tissue revealed a slight but definite alteration in its normal microscopic anatomy. Resorption cavities have begun to form among individual normal-appearing haversian canals (Fig. 4, *a* and *b*). The section stained with hematoxylin and eosin (Fig. 4, *c*) is contiguous to the one in Figure 4, *b*. Figure 4, *a* and *b*, should be compared with the microradiograph of normal cortical bone reproduced in Figure 3, *c*.

Polarized Light: Studies of normal cortical bone under polarized light have shown that the birefringent collagen bundles are circumferentially arranged in a normal haversian system (Fig. 5, *a*). In fully developed osteitis deformans the normal circumferential arrangement was replaced by a patchwork pattern of segments, although again an occasional properly oriented haversian system could be detected (Fig. 5, *b*).

POROTIC OSTEITIS DEFORMANS

Conventional Histologic Sections: In conventional histologic sections from por-

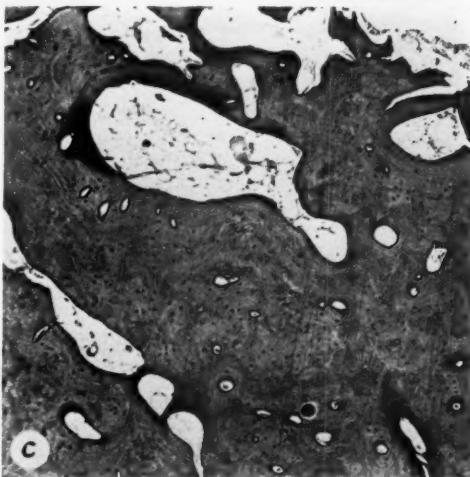


Fig. 4. *a*. Early changes in cortical bone at zone of transition from normal cortical bone to early Paget's disease. Haversian canals are enlarging and forming into absorption spaces. (Microradiograph: 10 kv; 14 ma.; 15 min.; $\times 25$.)

b. Changes in this section of cortical bone are a little more advanced than those in *a*. (Microradiograph: 15 kv; 15 ma; 15 min.; $\times 27$.)

c. Same area as demonstrated in *b*, being separated from it only by the thickness of the milling cut. (Hematoxylin and eosin. $\times 27$.)

otic osteitis deformans slender trabeculae or beams of bone were seen with abundant numbers of osteoblasts along the borders. No mosaic pattern was apparent, regardless of the technic of staining. Vascular sinuses were large and abundant. Marrow fat cells were numerous in foci (Fig. 6, *a*).

Microradiographs: The slender tra-

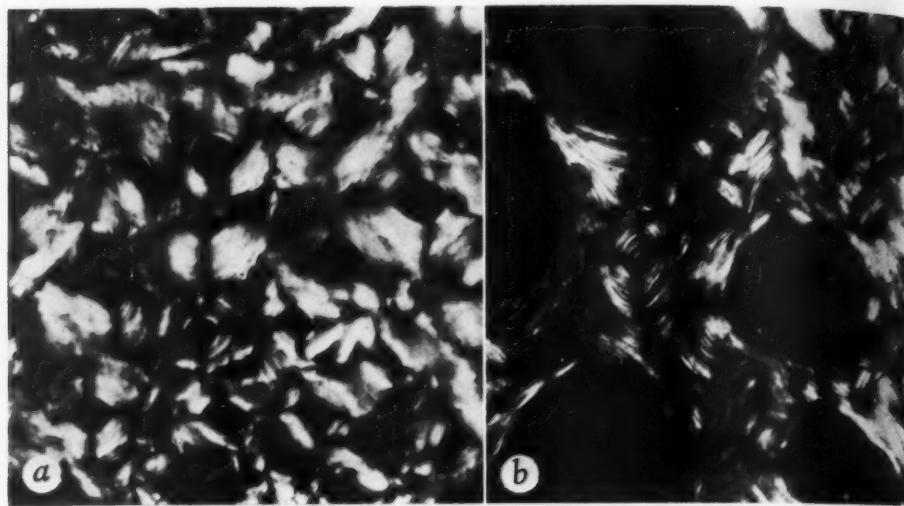


Fig. 5. Collagen bundles viewed under polarized light. *a.* Collagen bundles oriented in normal cortical bone. ($\times 100$.)
b. The collagen bundles appear normal here, but instead of forming a circumferential pattern they are arranged in a patchwork of segments. ($\times 100$.)

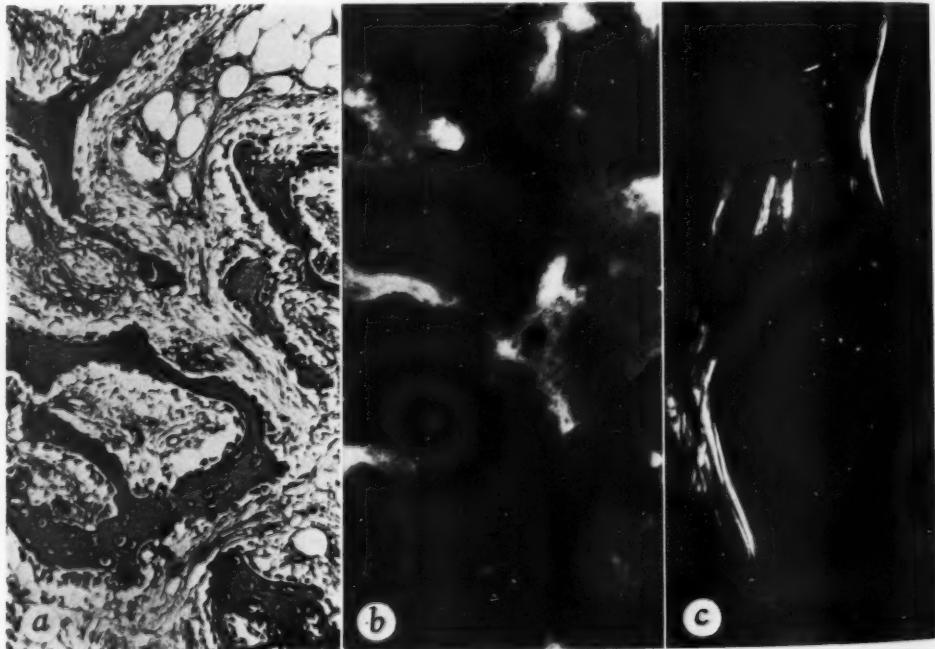


Fig. 6. Porotic osteitis deformans. *a.* Slender trabeculae are evident. The intertrabecular tissue is a vascular connective tissue. (Hematoxylin and eosin. $\times 110$.)
b. Microradiograph. The trabeculae when viewed individually are evenly mineralized (10 kv; 15 ma; 20 min.; $\times 110$).
c. Polarized-light view. Collagen bundles are arranged longitudinally. Their appearance is the same as that in a trabecula of normal cancellous bone. ($\times 140$.)

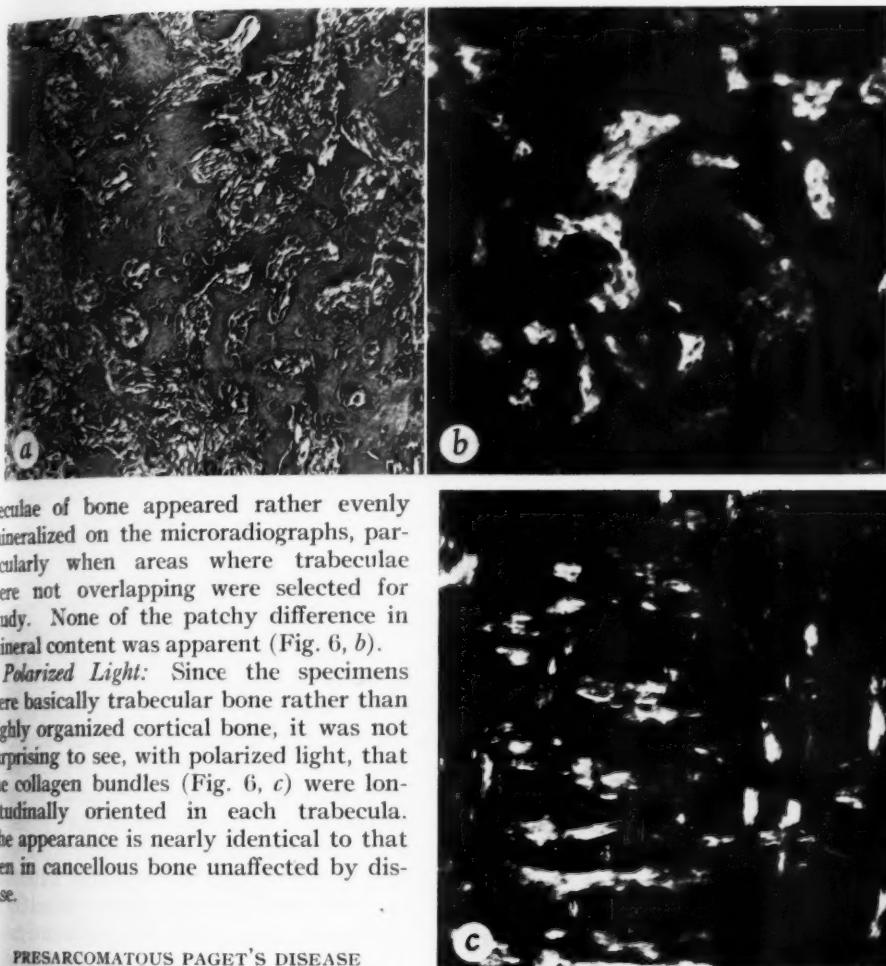


Fig. 7. Presarcomatous Paget's disease. *a*. The beams of bone are closely packed together. The intertrabecular tissue is made up of many cells with plump nuclei. (Hematoxylin and eosin. $\times 100$.)

b. Irregular mineralization of the beams of bone may be noted. (Microradiograph: 10 kv; 15 ma; 20 min. $\times 100$.)

c. Polarized-light view showing fragmentary and abnormal collagen. ($\times 140$.)

trabeculae of bone appeared rather evenly mineralized on the microradiographs, particularly when areas where trabeculae were not overlapping were selected for study. None of the patchy difference in mineral content was apparent (Fig. 6, *b*).

Polarized Light: Since the specimens were basically trabecular bone rather than highly organized cortical bone, it was not surprising to see, with polarized light, that the collagen bundles (Fig. 6, *c*) were longitudinally oriented in each trabecula. The appearance is nearly identical to that seen in cancellous bone unaffected by disease.

PRESARCOMATOUS PAGET'S DISEASE

Three specimens from the transition zone between true osteitis deformans and frank osteogenic sarcoma were selected for study. The difference between fully developed osteitis deformans and presarcomatous osteitis deformans was quite apparent, but the difference between the latter and osteitis deformans in the so-called porotic stage was less clear-cut. Our histologic and microradiographic criteria for osteogenic sarcoma are reported elsewhere (4).

Conventional Histologic Sections: Presarcomatous Paget's disease in a section stained with hematoxylin and eosin is illustrated in Figure 7, *a*. The presence, between the trabeculae, of numerous cells

with plump nuclei is striking. None of the vascularity seen with the other types of Paget's disease was observed, yet the stroma was not frankly malignant.

Microradiographs: In presarcomatous Paget's disease, the beams of bone appeared broader by microradiography than in porotic osteitis deformans and there was a distinct tendency to irregular mineralization

of the individual beams. The similarity of the two types of osteitis deformans is apparent, however, when the microradiographs of both are compared (Figs. 6, b and 7, b).

Polarized Light: Examination of presarcomatous Paget's disease under polarized light revealed an extremely fragmentary type of collagen orientation definitely different from that in the fully developed and porotic types (Fig. 7, c). The fragmentary appearance was similar to that reported in studies on osteogenic sarcoma (4).

COMMENT

The morphologic appearance of osteitis deformans has frequently been described. Microradiography, however, permits a more thorough examination of the alteration in mineralization of the bone. Our study seems to allow us to distinguish three sharply contrasted morphologic variants of the same disease process.

The appearance of the mineralized portion of the specimens seems distinct when fully developed osteitis deformans is compared with the porotic or presarcomatous type. In the fully developed form the remodeling process of cortical-bone growth has been completely disturbed by the growth and expansion of the contents of the haversian spaces and canals (Fig. 4). Although normal haversian architecture in this type of Paget's disease is hard to recognize, some semblance is still evident (Fig. 4, b). In the porotic stage the individual trabeculae are similar in many ways to normal cancellous trabeculae, particularly in that the mineralization and collagen structure are not unlike those of normal cancellous bone. In presarcomatous osteitis deformans the trabeculae in the mineralized portion of cancellous bone are thicker and more unevenly mineralized than the fine narrow trabeculae of the porotic type.

For study of the soft-tissue or stromal component, conventional techniques (sections stained with hematoxylin and eosin) are best. Presarcomatous osteitis deformans has a stroma of closely packed cells with plump nuclei, its characteristic morphologic appearance. The stromas in porotic and fully developed osteitis deformans are very similar, consisting of connective tissue that is vascular, loose in cellular arrangement, and the site of foci of marrow fat cells.

Although polarized light is not as refined a method of studying collagen as is electron microscopy, our observations indicate that a truly abnormal collagen is seen only in the presarcomatous type of Paget's disease. The mosaic pattern of fully developed osteitis deformans is, in our opinion, a reality and not an artefact. It can be shown by conventional technics as well as under polarized light and by microradiography. The latter seems to reveal that the pattern is due to a variable degree of mineralization of the bone and orientation of the collagen, since the same patchy arrangement is evident in polarized light studies.

SUMMARY

Fourteen specimens of osteitis deformans have been studied by microradiography, polarized light, and conventional histologic methods. Three morphologic types of the disease are distinguished. Fully developed and porotic osteitis deformans are roentgen entities well recognized by the radiologist. The third type, found in the transition zone between osteitis deformans and frank osteogenic sarcoma, "presarcomatous osteitis deformans," does not have a characteristic roentgenologic appearance. The morphologic features have been studied to illustrate differences and similarities in the mineral content, stromal structure, and collagen pattern.

Mayo Clinic
Rochester, Minn.

REFERENCES

1. BUTLIN: Quoted by Paget, James (8).
2. ENGFELDT, B., ENGSTRÖM, A., HELANDER, C. G., WILTON, Å., AND ZETTERSTRÖM, R.: Biophysical Studies on Bone Tissue. I. Paget's Disease. *Acta path. et microbiol. scandinav.* **31**: 256-261, 1952.
3. FROST, H. M.: Preparation of Thin Undecalcified Bone Sections by Rapid Manual Method. *Stain Technol.* **33**: 273-277, November 1958.

Vol. 77
L. F. A. Stu...
Methods
5. Path. 1
J. M.: radiog...
of Bone
Nov. 27
7. Disease
Osteom...
1925.
8. mati...
Chir. Sc

Osteit...
Dec...
form...
graphi...
histolo...
pholog...
prime...
de...
ben...
tie typ...
inter...
osteog...
appare...

Tam...
un pl...
minera...
distin...
vari...
typ...
c

4. HOLBERT, J. A., KELLY, P. J., PETERSON, L. F. A., AND DAHLIN, D. C.: Osteogenic Sarcoma: A Study Using Microradiography and Histologic Methods. *Arch. Path.* **71**: 20-27, January 1961.
5. JAFFE, H. L.: Paget's Disease of Bone. *Arch. Path.* **15**: 83-131, January 1933.
6. KELLY, P. J., PETERSON, L. F. A., AND JANES, J. M.: Ultrastructure of Bone: Technic of Microradiography and Its Possible Application to the Study of Bone. *Proc. Staff Meet., Mayo Clin.* **32**: 687-690, Nov. 27, 1957.
7. KNAGGS, R. L.: Osteitis Deformans (Paget's Disease) and Its Relation to Osteitis Fibrosa and Osteomalacia. *Brit. J. Surg.* **13**: 206-237, October 1925.
8. PAGET, JAMES: On a Form of Chronic Inflammation of Bones: (Osteitis Deformans). *Tr. Med.-Chir. Soc. London* **60**: 37-63, 1877.
9. SCHINZ, H. R., BAENSCH, W. E., FRIEDL, E., AND UEHLINGER, E.: *Roentgen-Diagnosics*. New York, Grune & Stratton, Inc., 1st American ed., (based on 5th German ed.), 1951, pp. 511-531.
10. SCHMORL, G.: Über Ostitis deformans Paget. *Virchows Arch. f. path. Anat.* **283**: 694-751, Feb. 29, 1932.
11. VIGLIANI, F.: Saggi di microradiografia del tessuto osseo in condizioni patologiche varie (in particolare nel morbo di Paget). *Ortop. e traumatol.* **24**: 623-633, July-September 1956.
12. WILKS: Case of Osteoporosis, or Spongy Hypertrophy of the Bones: (Calvaria, Clavicle, Os Femori, and Rib). *Tr. Path. Soc. London* **20**: 273-277, February 1868-69.
13. WRANY: Spongiöse Hyperostose des Schädelns, des Beckens und des linken Oberschenkels. *Vrtljschr. f. d. prakt. Heilk.* 1867, pp. 79-88.

SUMMARIO IN INTERLINGUA

Osteitis Deformante (Morbo de Paget de Osso): Un Studio Morphologic con le Uso de Microradiographia e de Technicas Conventional

Dece-quattro specimens de osteitis deformante esseva studiate per microradiographia, lumine polarisate, e methodos histologic conventional. Tres typos morphologic del morbo es distinguite: Le prime duo—plenamente disveloppate osteitis deformante e le typo porotic—es ben recognoscite per le radiologo. Le tertie typo, trovate in le zona de transition inter osteitis deformante e franc sarcoma osteogene, non manifesta un characteristic apparentia roentgenographic.

Tamen, le microradiographia permitte un plus detaliate examine del alterate mineralisation in le osso e rende possibile distinguere un nette contrasto inter le tres variantes. In le plenamente disveloppate typo de osteitis deformante, le processo

remodulatori in le crescentia de osso cortical es completamente disturbate per le crescentia e le expansion del contento del spacios e canales haversian. Ben que le normal architectura haversian es difficile a recognoscere, un certe similitude remane evidente. In osteitis deformans pre-sarcomatose, le trabeculas in le mineralisate portion de osso cancelloso es plus spisse e mineralisate minus uniformemente que le delicate e fin trabeculas del typo porotic.

Ben que le methodo a lumine polarisate non es tanto raffinate como le microscopia electronic in le studio de collageno, le observationes del autores pare indicar que un collageno vermente anormal es incontrate solmente in le typo pre-sarcomatose de morbo de Paget.



Comparison of Intraosseous Vertebral Venography and Pantopaque Myelography in the Diagnosis of Surgical Conditions of the Lumbar Spine and Nerve Roots¹

ROBERT A. SCHOBINGER, M.D., ERICH G. KRUEGER, M.D., and GARRISON L. SOBEL, M.D.

DESPITE THE widespread use and claimed safety of Pantopaque myelography (1-7) many still adopt a reluctant attitude toward its indiscriminate and repeated employment or condemn it as a screening procedure. The basis for this hesitancy are reports of occasional adverse reactions of the leptomeninges with early or late sequelae in the spinal canal or intracranial cavity. A method without the disadvantages associated with the introduction of a potentially irritating substance into the subarachnoid space but with comparable accuracy, even if limited to lesions of the lumbar spine, would indeed constitute a valuable addition to our diagnostic armamentarium. It was our feeling that intraosseous vertebral venography might hold such promise. We therefore set out to compare its potentialities with those of Pantopaque myelography in the diagnosis of such surgical lesions of the lumbar spine and nerve roots as disk protrusion, spondylolisthesis, symptomatic spina bifida occulta, tumors of the cauda equina, epidural tumors, and metastatic tumors of the vertebral column.

ANATOMIC CONSIDERATIONS

The blood from the medulla spinalis, nerve roots, meninges, vertebral column, and paravertebral muscles is drained by multiple veins constituting a network extending over the entire length of the spine. These venous plexuses are located in part outside and in part inside the spinal canal (Fig. 1).

The *external vertebral venous plexus* surrounds the vertebral column and is best

developed in the cervical region, an anatomic peculiarity which has been roentgenographically verified (8, 9). Its posterior division is located along the spinous processes and the posterior surface of the transverse processes, extending also between the posterior paravertebral muscles. The anterior division is situated laterally and anteriorly to the vertebral bodies and is linked to its posterior counterpart as well as to the internal vertebral plexus (Fig. 1). The external vertebral venous plexus assumes important collateral circulatory duties in the presence of some obstruction to the blood flow within the internal vertebral venous plexus.

The *internal vertebral venous plexus*, which we prefer to call the *epidural plexus*, is located within the spinal canal between the dura and the bony surfaces of the vertebrae. The epidural veins run along the entire length of the spine and their anatomical continuity with the intracranial dural sinuses has been confirmed by Batson (10). The veins of the internal vertebral plexus surround the spinal dura and form two pairs of well developed longitudinal channels connected with each other by a series of venous rings, one opposite each vertebra. The epidural veins are furthermore connected to the external vertebral venous plexus and to two important veins: the basivertebral and the intervertebral (Fig. 1), the former draining blood directly from the vertebral body, the latter accompanying the nerve root sleeve, to be joined by radicular veins from the spinal cord and cauda equina. The intervertebral veins thus serve as outlets for the internal and external vertebral

¹ From the General Surgical and Neurosurgical Sections (Surgical Service), Bronx Veterans Administration Hospital; the Department of Surgery, Albert Einstein College of Medicine; the Department of Neurological Surgery, College of Physicians and Surgeons, Columbia University, New York, N. Y. Accepted for publication in February 1961.

Selected illustrations reproduced from Schobinger, R.: Intra-osseous Venography, by permission of Grune & Stratton, Inc.

venous plexuses into segmental body veins, which, caudad to cephalad, are the lateral sacral, lumbar, posterior intercostal, and vertebral veins. This anatomic arrangement allows collateral shunting in either direction between the vertebral plexuses and inferior and superior caval circulations. It is the system of epidural and intervertebral veins and the alterations of their physiologic and/or pathologic patterns which form the basis of venographic diagnosis.

slight modification, the simple principle of abdominal compression routinely employed in excretory urography. Since the technic of lumbosacral intraosseous venography has been presented in detail elsewhere (12) only certain important aspects of the method will be mentioned here.

The patient is placed in the prone position on a wedge-shaped film tunnel on top of which lies an inflatable balloon (Fig. 2, A). This position is often better tolerated by patients with acute low back

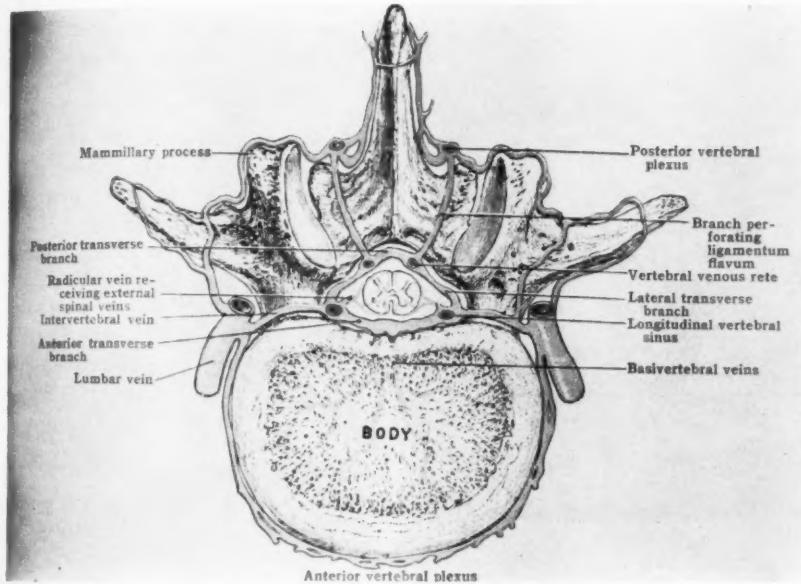


Fig. 1. Drawing of veins of the vertebral column.

TECHNIC

Adequate sedation is obtained by the administration of Demerol (100 mg.) and Seconal (100 mg.) one hour prior to intraosseous vertebral venography, a procedure which is preferably performed on a fasting patient.

Excellent opacification of the epidural veins can be achieved by temporarily occluding the inferior vena cava (11). This maneuver results in the prompt shunting of inferior vena cava blood through readily available collaterals, including the all-important system of epidural veins. For this purpose we have adopted, with a

pain than the flat prone position. The tunnel holds a 10 × 12-inch film in a stationary grid cassette. A slightly overexposed scout film of the lumbar spine with the shortest possible exposure time is always obtained and a spinous process, preferably one vertebra caudad to the level of suspected abnormality, is identified. Occasionally, however, proper cannulation of a very narrow sacral spinous process may be difficult or even impossible, and in such instances the spinous process of L5 may be selected in an attempt to opacify the epidural plexus of the L5-S1 interspace in retrograde fashion. Under

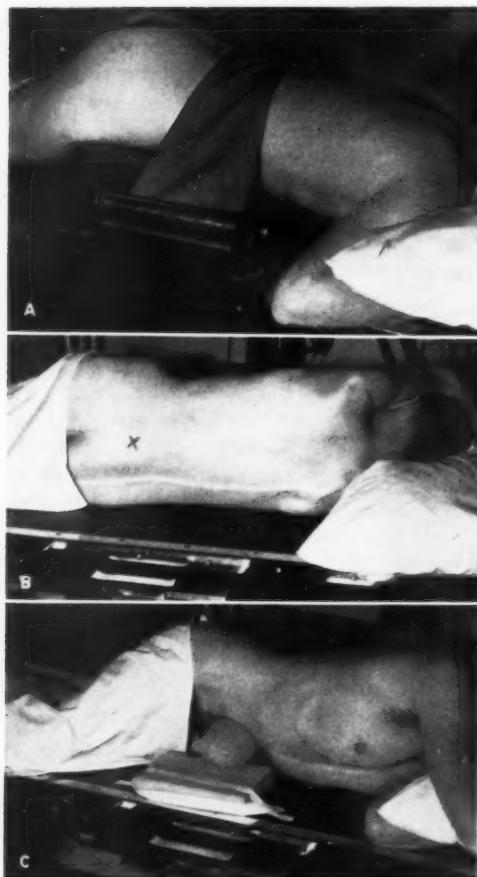


Fig. 2. A. Correct positioning of patient on wedge-shaped cassette holder for venograms in the posteroanterior projection. X-ray tube must be tilted according to inclination of film. X indicates site of bone puncture.

B. Correct positioning of patient for intraosseous epidural venograms in a lateral projection. A 14 × 17-inch film contained in a movable Bucky diaphragm is employed.

C. Correct positioning of patient for oblique views. Balsa wood ball compresses inferior vena cava.

local anesthesia, a 16-gauge Rosenthal bone-marrow needle is introduced into the medullary cavity of the spinous process by a rotary motion of the hand. Peripheral blood containing bone-marrow particles *must* be freely aspirated prior to the injection of any substance. Strict adherence to this rule will prevent inadequate injections.

After correct placement of the needle, 2 to 3 c.c. of 2 per cent procaine is in-

jected directly into the marrow cavity. One or two minutes thereafter, an average of 25 c.c. of 50 per cent Hypaque is rapidly introduced within five seconds or less after tightening of the constriction band and adequate inflation of the compression balloon. One film exposed *during* the injection of the last 2 or 3 c.c. of contrast medium is immediately developed and will furnish the desired information. If the venogram is technically and diagnostically satisfactory, the needle may be withdrawn and a small sterile dressing applied. Special aftercare is not required.

Venograms obtained in the posteroanterior projection are most informative. We customarily add a venogram in a straight lateral projection (Fig. 2, B) while the patient is executing a Valsalva maneuver. This view furnishes additional information in some cases. It must be realized that the ascending lumbar veins occasionally tend to overlap the epidural veins on lateral views, thus rendering difficult a detailed analysis of the various venous structures. Oblique views with temporary compression of the inferior vena cava may be helpful (Fig. 2, C).

REPRESENTATIVE VENOGRAPHIC FINDINGS

This report encompasses 68 patients with a variety of lesions involving the bony and/or neural elements of the vertebral column (Table I). The venographic findings representative of the various groups will be discussed.

Normal Venograms

In normal venography, the contrast medium promptly escapes from the medullary cavity of the injected bone into the external and internal vertebral venous plexuses. Since the blood in the epidural veins lacks, for all practical purposes, a direction of flow in the normal resting individual placed in the horizontal position, the radiopaque material outlines these plexuses in cephalad and caudad direction usually over only a few vertebral spaces. This is best observed in the lateral view without compression of the

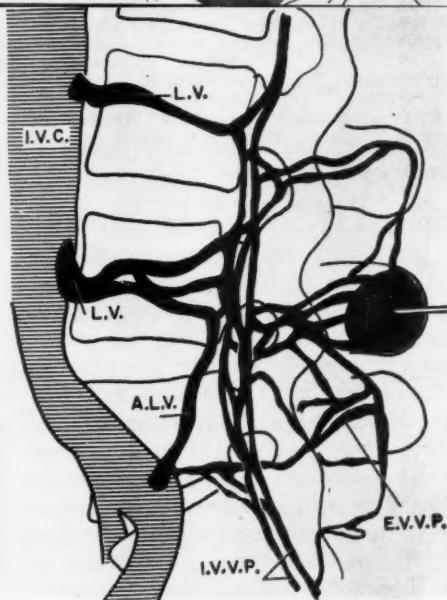
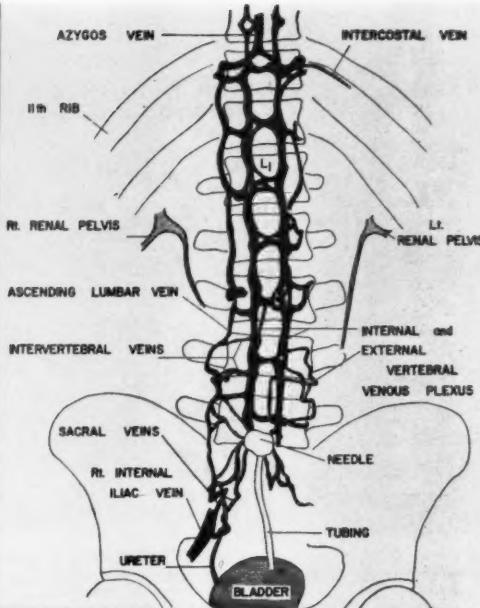


Fig. 3. A. Normal postero-anterior epidural venogram. Note paucity of retrograde flow and excellent visualization of epidural and intervertebral veins over entire lumbar spine. Inferior vena cava temporarily compressed. B. Normal lateral epidural venogram without compression of the inferior vena cava or Valsalva maneuver. External (E.V.V.P.) and internal (I.V.V.P.) vertebral venous plexuses outlined in cephalad and caudad directions, with opacification of the inferior vena cava over lumbar veins. Ascending lumbar veins (A.L.V.) occasionally overlap the internal vertebral venous plexus (epidural veins), rendering detailed study of the latter veins impossible in this projection. L. V. Lumbar vein.

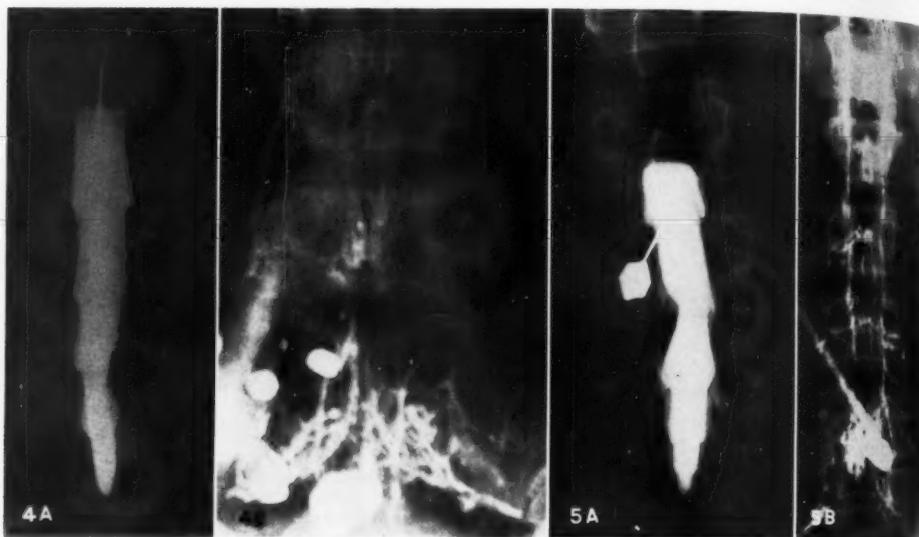


Fig. 4. Intervertebral disk protrusion L5-S1, left.

A. Myelogram. Indentation of Pantopaque column at the L5-S1 interspace, left, with filling defect of the left S1 root sleeve.

B. Intraosseous venogram, same patient. Medium injected into spinous process of S2. Epidural veins in L5-S1 interspace well outlined on right but thinned and spread out on left (arrow). Venous plexus well opacified cephalad and caudad to lesion. Diagnosis confirmed at surgery.

Fig. 5. Intervertebral disk protrusion L4-L5, right.

A. Myelogram. Indentation of the Pantopaque column at the L4-L5 interspace, right, with shortening of the right L5 root sleeve.

B. Epidural venogram, same patient. Hypaque injected into spinous process of L5. Filling defect in epidural plexus at L4-L5, right. Plexus on the left as well as cephalad and caudad well outlined. Note lack of opacification of intervertebral vein corresponding to level of lesion. Compare with normal left side (arrow). Diagnosis confirmed at operation.

inferior vena cava (Fig. 3, B). If, however, this latter vein is temporarily occluded, a definite cephalad direction of flow within the internal vertebral venous plexus does occur. Normally, the system of epidural veins appears in the posteroanterior projection as a continuous ladder of venous structures. The intervertebral veins are also opacified over many intervertebral spaces and are seen to drain into the laterally situated ascending lumbar veins. The opacification of these various venous structures appears bilaterally equal (Fig. 3, A). Deviations from this continuous pattern connote an obstruction affecting the flow within the vertebral venous plexuses cephalad to the level of injection.

Lumbar Disk Protrusions

The protrusion of an intervertebral disk into the spinal canal usually leads to

compression of nerve sleeves, dural sac, and vascular structures. Venography is a sensitive indicator of displacements or obstructions of the epidural veins. We have found that the most informative angiograms in this particular type of lesion are those obtained in the posteroanterior projection, with temporary occlusion of the inferior vena cava, and the remarks in this paragraph refer primarily to observations made on such views. With increasing compression or deviation of the epidural veins, an augmented degree of collateral circulation *via* the external vertebral venous plexus and ascending lumbar veins can be observed. Furthermore, there is also evidence of flow of contrast medium in a distal direction to a degree not observed under normal conditions. Such a retrograde flow suggests stasis within the vertebral venous circulation and is commonly more pronounced

on the side of the disease process. Usually, the intervertebral vein corresponding to the level of the lesion is not opacified. Conversely, the ascending lumbar veins and the external vertebral plexus may be more densely opacified than normal since they are called upon to assume a greater collateral circulatory function.

In mild disk protrusions only a lateral deviation or mere thinning of the epidural veins corresponding to the level of the lesion is observed on frontal views, and a posterior displacement is seen on the lateral projection (Figs. 4 and 5). In pronounced herniations, however, a complete interruption of the epidural veins occurs, with rather prompt re-establishment of the roentgenographic continuity of these veins cephalad to the lesion (Fig. 6). In these instances of total epidural venous block, the contrast medium is seen to reach the internal vertebral venous plexus again through the external vertebral plexus and ascending lumbar veins. These somewhat subtle points are emphasized because they assume importance in the differential diagnosis between benign lesions and metastatic tumors of the lumbar spine.

Congenital Anomalies

Spondylolisthesis: The venographic pattern may appear intact with only slight localized posterior displacement of the epidural veins in the presence of a minimal shift of the fifth lumbar vertebral body. On the other hand, a marked anterior displacement of the body of that vertebra in relation to the sacrum (Fig. 7) may result in pronounced alterations of the venographic picture and even in total epidural venous obstruction of the type observed in the following anomaly.

Painful Spina Bifida Occulta: The venogram in our patient with spina bifida occulta showed a complete obstruction of the epidural plexus at the upper level of the first sacral vertebra (Fig. 8). Surgical exploration revealed the replacement of the lamina of S1 by a cartilaginous remnant suspended loosely on yellow ligament

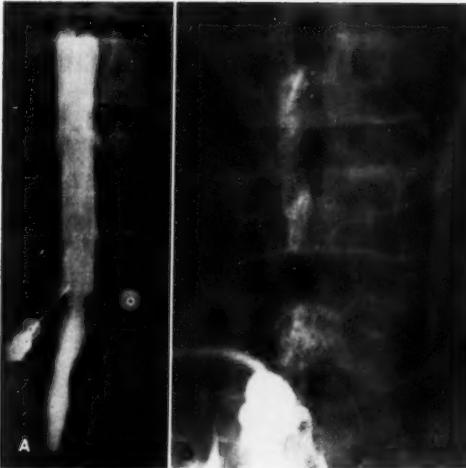


Fig. 6. Intervertebral disk protrusion L5-S1, left.
A. Myelogram. Indentation of Pantopaque column at L5-S1 interspace, left, with shortening of left S1 root sleeve.

B. Epidural venogram, same patient. Contrast medium injected into spine of S1. Obvious filling defect on the left at the L5-S1 interspace with good opacification of a broad plexus on the right and bilaterally cephalad to L5. Diagnosis surgically verified.

yielding easily to pressure. This finding explained the mechanism of neural compression by impingement of the spinous process of L5 upon the remnant of S1 when the patient extended the lumbo-sacral spine. Hence, a complete obstruction of the epidural veins reflects the mechanical factor causing narrowing of the spinal canal and compression of the neural elements.

Intradural Neoplasms

Two patients with intradural tumors were examined by venography. The diagnosis in both instances was confirmed by myelography and subsequent surgery, with histologic confirmation of ependymoma of the cauda equina in 1. The venographic pattern in this latter patient was somewhat different from that observed in metastatic tumors. The basic pattern was of the occlusive type seen in vertebral metastases, but contrast medium was again visualized proximal to the tumor, outlining it to some degree (Fig. 9). The venogram gave the impression that contrast medium had been squeezed from the epidural

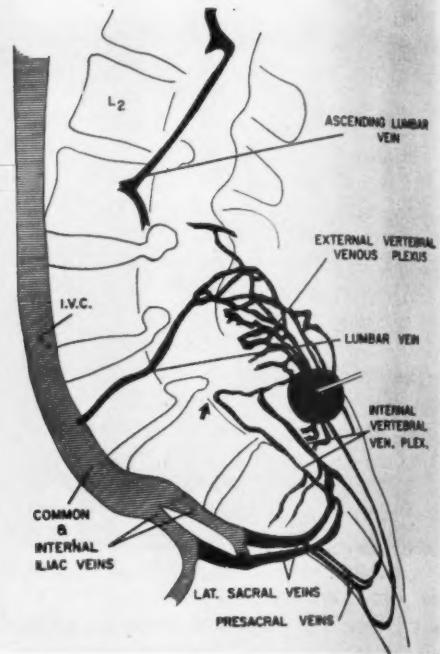


Fig. 7. Spondylolisthesis. Lateral intraosseous epidural venogram. Medium injected into spine of S1. Total block of epidural plexus (arrow) with marked collateral and retrograde flow. In mild spondylolisthesis only a posterior deviation of the anterior portion of the epidural plexus may be present.

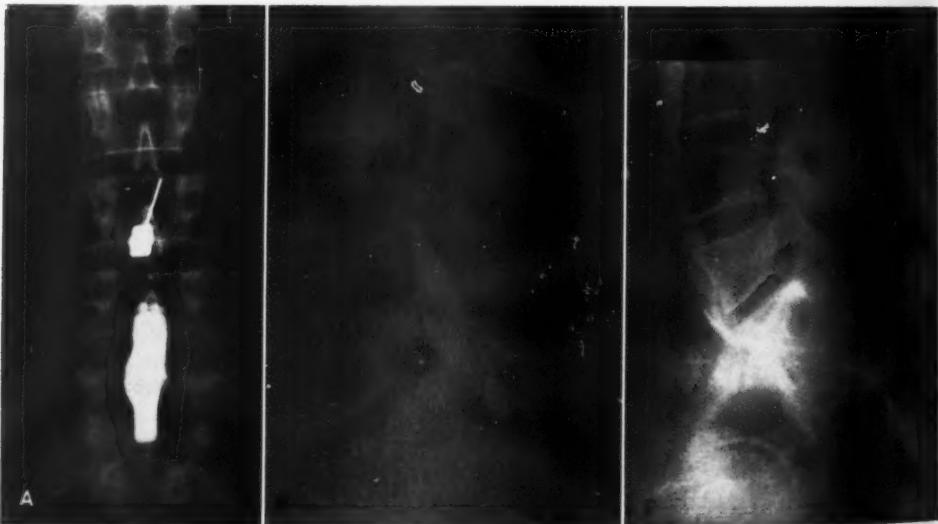


Fig. 8. Painful spina bifida occulta, S1.

A. Myelogram. Slight shortening of the left S1 root sleeve. Cartilaginous replacement of lamina of involved vertebra.

B. Myelogram, lateral projection, same patient. Abnormally great distance between posterior border of vertebral bodies and anterior aspect of Pantopaque column at L5-S1 level.

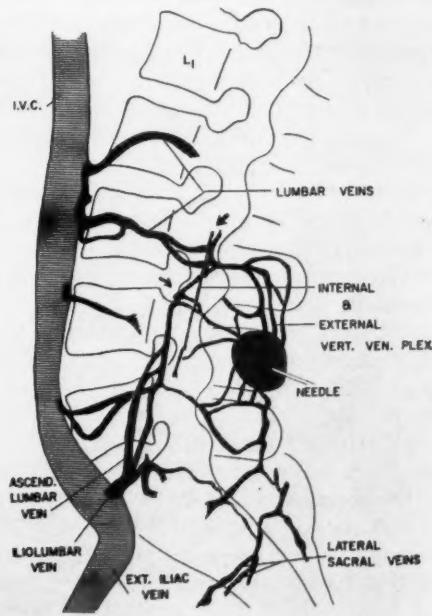
C. Epidural venogram, same patient. Medium injected into S1 spinous process. Complete block of epidural plexus at L5-S1 interspace with marked retrograde flow. Unsuccessful initial attempt to properly cannulate and inject S1 spinous process explained by cartilaginous (avascular) replacement of that spinous process. Diagnosis confirmed at surgery.



Fig. 9. Ependymoma of cauda equina.

A. Myelogram. Well circumscribed, typical filling defect with filiform downward extension into Pantopaque column.

B. Epidural venogram, same patient. Injection into spinous process of L4. Posterior portion of epidural plexus obliterated at level of L3 (upper arrow) with inferoposterior deviation of intervertebral vein at L3-L4 interspace (lower arrow). Contrast medium visible in lumbar veins at level of lesion. Considerable retrograde flow. Venogram outlines extent of tumor (compare with myelogram). Diagnosis of intradural tumor extending from mid L2 to L3-L4 interspace confirmed at surgery.



veins, the latter being compressed by the intradural mass.

An even more pronounced obliteration of the epidural veins was present in a patient with an intramedullary glioma extending from the lower cervical to the upper dorsal spine. Injection of contrast medium into the spinous process of C6 revealed a complete block of the epidural veins with shunting of the radiopaque substance over dilated veins of the external vertebral plexus.

Adhesive Arachnoiditis

Since Pantopaque myelography may cause adhesive arachnoiditis, its use in

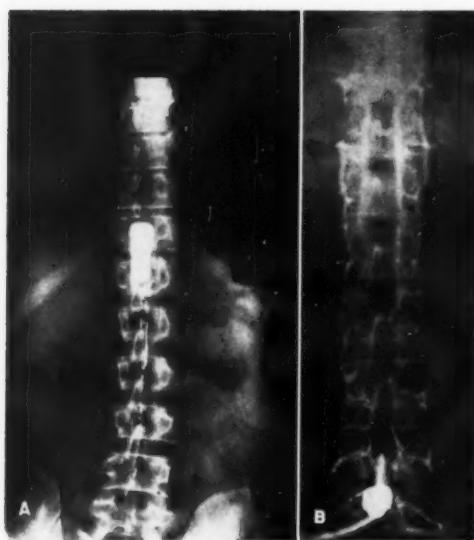


Fig. 10. Adhesive arachnoiditis.

A. Myelogram. Total block at level of L1 as demonstrated by lumbar and cervical instillation of Pantopaque. Note typical streaky appearance of Pantopaque column.

B. Epidural venogram, same patient. Injection performed into L5 spinous process (patient having 6 lumbar vertebrae). Entirely normal venogram.

patients already afflicted with that condition is not desirable, although necessary to establish the diagnosis or to rule out the presence of an intraspinal tumor. Therefore, and also for reasons of comparison, contrast myelography and vertebral venography were purposely performed in 2 patients with a diagnosis of adhesive arachnoiditis, surgically confirmed in 1 instance and presumptive in the other. Findings on vertebral venography were normal in both cases, while myelography showed a typical streaky appearance of contrast medium with total block in the proved (Fig. 10) as well as in the unconfirmed case. Venography thus furnished supplementary data, ruling out the presence of a tumor, a possibility which had to be considered on the basis of either clinical or myelographic findings. The necessity of myelography may be averted under these circumstances.

Vertebral Metastases

The angiographic pattern of the verte-

bral venous circulation is rather typical in the presence of malignant lesions involving the spine. In contradistinction to the vascular pattern in protruded intervertebral disks, there is complete interruption of the flow of contrast medium at the level of the neoplastic process. With

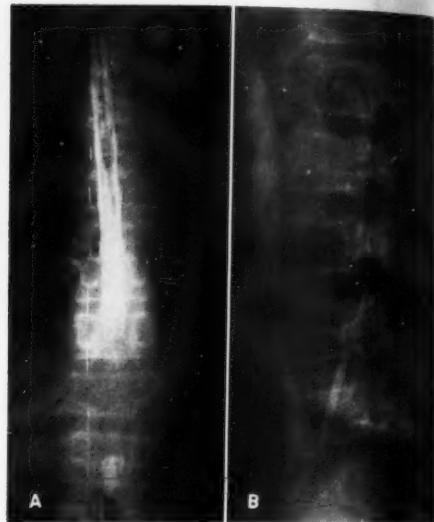


Fig. 11. Metastatic renal-cell carcinoma.

A. Cisternal myelogram. Total block at upper border of T11. Destructive process involving T12. Lumbar myelogram (not illustrated) revealed filling defect cephalad to L3 with complete block at L1.

B. Epidural venogram. Hypaque injected into spinous process of L4. Total block of epidural veins at upper border of L4. No cephalad but marked retrograde flow of contrast medium. Although vertebrae appear normal at this level, the total venographic block indicates presence of neoplasm. This was confirmed by surgery and histology.

lateral views only, this observation has been made in all instances of malignant deposits, thus confirming previously reported venographic findings in osteolytic, osteoblastic, and intertrabecular metastases (12-16). Frequently the intervertebral, lumbar, and ascending lumbar veins appear obstructed in the vicinity of the neoplasm. With the flow of contrast medium within the epidural veins taking place toward the heart under the conditions prevailing during intraosseous vertebral venography (inferior vena cava compression or Valsalva exercise), contrast substance is usually absent in the epidural



veins cephalad to the lesion (Figs. 11 and 12).

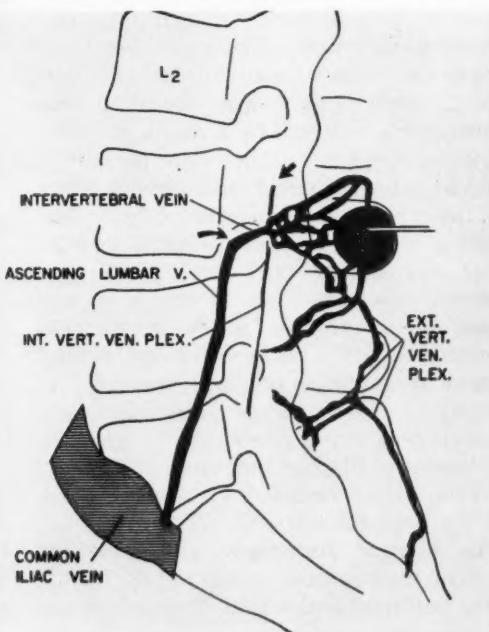
Radiation Myelitis and/or Radiculopathy

Irradiation of the retroperitoneal space for primary or metastatic malignant lymphadenopathy cannot always be planned in such a manner as to exclude the neural structures from the beam of ionizing radiation. Permanent neurologic disturbances following radiation therapy to this area are unusual, but the incidence of radiation myelitis following treatment of carcinoma of the testis with doses exceeding 5,000

Fig. 12. Intervertebral disk protrusion, L4-L5, combined with metastatic anaplastic carcinoma (parotis) involving L3.

A. Myelogram. Narrowing of Pantopaque column at L4-L5 interspace with shortening of left L5 root sleeve. Detailed study revealed free flow of Pantopaque over entire lumbar spine cephalad to L4-L5 interspace.

B. Epidural venogram, same patient. Contrast medium injected into L3 spinous process. Complete block of epidural veins at level of L3 with marked retrograde flow. Since anterior portion of epidural venous plexus was not outlined, herniation of intervertebral disk at L4-L5 could not be established. Myelography was indicative of a disk at that level but not of carcinoma (intertrabecular) involving L3. Biopsy of L3 spinous process during laminectomy for bilateral removal of large herniated L4-L5 disk confirmed the presence of neoplasm.



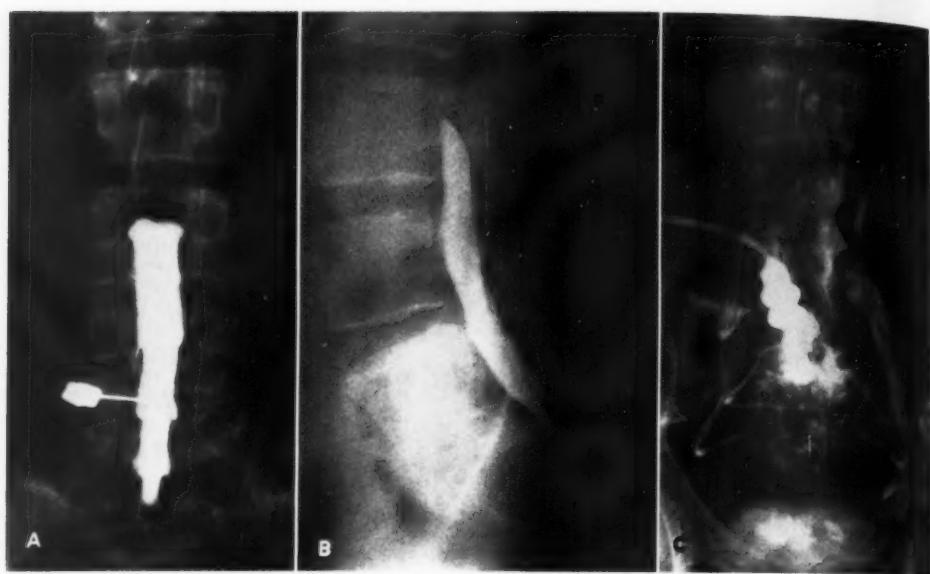


Fig. 13. Radiation myelitis and/or radiculopathy.

A and B. Myelograms revealing normal aspect of Pantopaque column in frontal and lateral views. C. Epidural venogram, same patient. Injection performed into spinous process of S2. Several attempts to aspirate blood from the spinous processes of L4 to S1 were unsuccessful. Venogram reveals total block at L5. Mild extravasation of medium along left posterior paravertebral muscles; marked retrograde flow. Venographic diagnosis of probable metastatic tumor. Laminectomy and biopsy revealed avascularity of bone and epidural tissues within radiation portals but no neoplasm.

r has been reported to be as high as 10 per cent (17, 18). Our patient who on surgical exploration was found to fall into this category underwent orchiectomy for seminoma six years prior to intraosseous vertebral venography. The operation was immediately followed by a course of radiation therapy for a tumor dose of 2,000 r to the retroperitoneal area and 2,400 r to the right inguinal region. Two years later a second identical course of irradiation was administered for clinically recurrent disease. The neurologic symptoms of motor and reflex impairment started twelve months after the second course of radiotherapy and became progressively worse, with subsequent appearance of sensory impairment and disturbances of bladder function.

Venography revealed a complete block of the epidural veins at the level of L5, with marked retrograde and collateral flow of the contrast medium (Fig. 13, C). This pattern mimics that observed in the presence of vertebral metastases. Several

TABLE I: CASE MATERIAL

Diagnosis	Venogram	Myelogram	Operation
Lumbar disk protrusions			
L5-S1	13	11	13
L4-L5	18	16	18
L3-L4	1	1	1
L2-L3	1	1	1
Radiculitis, unconfirmed surgically or of unknown origin			
	21	8	2
Congenital malformation			
Spina bifida	2	2	2
occulta	1	1	1
Intradural tumors			
Adhesive arachnoiditis	2	2	1
Metastatic tumors	6	6	6
Radiation myelitis or radiculopathy	1	1	1
TOTAL	68	51	48

spinous processes had to be punctured before one was encountered which allowed aspiration of some peripheral blood containing marrow elements; even this yield was minimal. Two previous myelograms

TABLE II: VERIFIED LUMBAR DISK PROTRUSIONS (D.P.)

Clinical	Venographic Diagnosis	Myelographic Diagnosis	Operative Diagnosis
<i>Disk Protrusion L5-S1 Interspace</i>			
1. Radiculitis S1, Rt.	D.P. L5-S1, Rt.	Same	Same
2. Radiculitis S1, Lt.	D.P. L5-S1, Lt.	Same	Same
3. Radiculitis S1, Lt.	D.P. L5-S1, Lt.	Same	Same
4. Radiculitis S1, Lt.	D.P. L5-S1, Lt.	Same	Same
5. Radiculitis S1, Lt.	D.P. L5-S1, Lt.	Same	Same
6. Radiculitis S1, Lt.	D.P. L5-S1, Lt.	Same	Same
7. Radiculitis S1, Lt.	Technical failure	D.P. L5-S1, Lt.	Same
8. Radiculitis S1, Rt.	D.P. L5-S1, Rt.	Same	Same
9. Radiculitis S1, Lt.	D.P. L5-S1, Lt.	Same	Same
10. Radiculitis S1, Lt.	D.P. L5-S1, Lt.	None	Same
11. Radiculitis L5 and S1, Lt.	D.P. L5-S1, Lt. and midline	Not diagnostic	D.P. L5-S1, Lt. and midline
12. Radiculitis L5 and S1, Lt.	D.P. L5-S1, Lt.	D.P. L5-S1, midline	D.P. L5-S1, Lt.
13. Radiculitis S1, Lt. > Rt. (status postoperative removal D.P. L5-S1, Rt.)	D.P. L5-S1, Lt. and midline	None	D.P. L5-S1, midline, Rt. > Lt.
<i>Disk Protrusion L4-L5 Interspace</i>			
1. Radiculitis L5 and S1, Rt.	D.P. L4-L5, Rt.	D.P. L4-L5, Rt. and midline	D.P. L4-L5, Rt. and midline
2. Radiculitis L5, Rt.	D.P. L4-L5, Rt.	Suggestive of D.P. L4-L5, Rt.	D.P. L4-L5, Rt.
3. Radiculitis L5 and S1, Lt.	D.P. L4-L5, Lt. and midline	Same	Same
4. Radiculitis L5, Rt.	D.P. L4-L5, Rt.	Same	Same
5. Radiculitis L5 and S1, Rt.	D.P. L4-L5, Lt. and midline	D.P. L4-L5, midline	D.P. L4-L5, Rt. and midline
6. Radiculitis L5 and S1, Rt.	D.P. L4-L5	D.P. L4-L5 Rt.	Same
7. Radiculitis L5, Rt.	D.P. L4-L5, Rt.	Same	Same
8. Radiculitis L5, Lt.	D.P. L4-L5, Lt. and midline	D.P. L4-L5, Lt.	D.P. L4-L5, Lt.
9. Radiculitis L5, Lt.	D.P. L4-L5, Lt.	Same	Same
10. Radiculitis S1, Lt.	D.P. L4-L5, Lt.	None	D.P. L4-L5, Lt.
11. Radiculitis L4, Lt.	D.P. L4-L5, Lt.	Same	Same
12. Radiculitis L5, Lt.	D.P. L4-L5, Lt.	Same	Same
13. Radiculitis L5, Lt.	D.P. L4-L5, midline	Same	Same
14. Radiculitis L5 and S1, Rt.	D.P. L4-L5, Rt.	None	D.P. L4-L5, Rt.
15. Radiculitis L5, Lt.	D.P. L4-L5, Lt.	Same	Same
16. Radiculitis L5 and S1, Rt.	D.P. L4-L5, Rt. and midline	None	D.P. L4-L5, Rt. and midline
17. Radiculitis L5, Rt. and S1, Rt. > Lt.	D.P. L4-L5, Rt. and midline	D.P. L4-L5, Rt.	D.P. L4-L5, Rt. and midline
18. Radiculitis L5, Lt.	D.P. L4-L5, Rt.	Same	Same
<i>Disk Protrusion L3-L4 Interspace</i>			
1. Radiculitis L4, Rt. > Lt.	D.P. L3-L4, midline	Same	Same
<i>Disk Protrusion L2-L3 Interspace</i>			
1. Radiculitis L3 and L4, Lt.	D.P. L2-L3, Lt.	Same	Same

TABLE II A: SUMMARY OF RESULTS IN VERIFIED DISK PROTRUSIONS (D.P.)

Level	No. of Procedures	Correct	Suggestive	Level Correct; No Lateralization	Not Diagnostic	Technical Failure	No Examination
<i>L5-S1</i>							
Venogram	13	12	..	..	1	1	1
Myelogram	11	9	..	1	1	..	2
<i>L4-L5</i>							
Venogram	18	16	..	2	..	..	..
Myelogram	15	12	1	2	..	..	3
<i>L3-L4</i>							
Venogram	1	1	..	..	..	..	..
Myelogram	1	1	..	..	..	..	..
<i>L2-L3</i>							
Venogram	1	1	..	..	..	..	..
Myelogram	1	1	..	..	..	..	..
<i>TOTAL</i>							
Venogram	33	30	..	2	1	1	..
Myelogram	28	23	1	3	1	..	5



Fig. 14. Pneumoencephalogram with deposits of Pantopaque in basal cisterns and subarachnoid spaces of sulci of both hemispheres. Pantopaque was introduced during cervical myelography performed in another hospital nine months prior to this study. Patient began to complain of headaches and numbness of face and body on the left, approximately one month after myelography.

had been interpreted as normal (Fig. 13, A and B), and bone biopsies had failed to demonstrate metastatic tumor.

COMPARISON OF RESULTS OF VENOGRAPHY AND MYELOGRAPHY

Venography was carried out in 65 patients with neurosurgical disorders and in 3 with orthopedic conditions (Table I). Except for 1 patient with a metastatic carcinoma of the lower thoracic spine and another with an intramedullary glioma of the lower cervical region, all exhibited symptoms of disease of the lumbar spine and/or meninges and nerve roots.

In the group of verified disk protrusions, the clinical, venographic, myelographic, and operative diagnoses are listed for each case (Table II) and summarized in a composite tabulation (Table IIA). The venographic diagnosis was correct in 30 out of 33 instances and partially correct

in an additional 2, with 1 technical failure. Myelograms were obtained in only 28 cases; the diagnosis was correct in 23, suggestive in 1, partially correct in 3, and not diagnostic in 1. In disk protrusion at the L5-S1 interspace, the diagnostic accuracy of venography appears equal to that of myelography and even slightly superior.

In the group of patients with radiculitis and low-back symptoms of unverified or miscellaneous origin, a comparison of the two methods is difficult since myelography was carried out in only 10 of the 21 patients. The venographic findings in 14 instances, however, supported the clinical diagnosis or suspicion of a root compression. We also considered the aid of venography rather important in excluding organic lesions in 3 out of 5 patients with psychotic or neurotic symptoms (Tables III and IIIA).

The third group of 14 patients with various lesions (congenital malformations, tumors, adhesive arachnoiditis and radiation myelitis) is presented in Table IV with a summary of the results in Table IVA. The tabulations are self-explanatory and indicate the superiority of venography in the group of metastatic lesions as presented in more detail in the discussion.

There were 3 technical failures in the course of this study: 2 during intraosseous venography and 1 after myelography. Those occurring during epidural venography were due to extravasation or injection of contrast medium (50 per cent Hypaque) into the epidural space. In both instances unusually pronounced pain localized in the back and radiating into both lower extremities was experienced. Urinary retention requiring catheterization was present in 1 case but subsided after twenty-four hours. No other immediate or late sequelae were observed in either instance.

Both of these complications occurred because two basic rules governing successful intraosseous venography were not observed. In one patient a high-pressure mechanical device was employed to inject contrast medium through a properly

al failure.
28 cases:
suggestive
not diag-
n at the
accuracy
that of
superior.
radiculitis
erified or
on of the
graphy
e 21 pa-
s in 14
the clinical
compression
of venog-
excluding
ents with
(Tables

ts with
nations,
d radi-
able IV
n Table
anatory
graphy
as pre-
sion.

in the
y intra-
myelog-
epidural
ation or
per cent
ce. In
ed pain
ing into
experi-
ization
d after
mediate
either

occurred
success-
not ob-
pressure
to in-
properly

placed needle. The epidural extravasation of contrast medium must therefore have been secondary to the rupture of an epidural vein caused by the transmission of the highly increased intraosseous pressure. In the second instance, contrast medium was injected directly into the sacral epidural space following the faulty placement of the bone-marrow needle. The error in the first case consisted in the use of a mechanical injector which we condemn for intraosseous venography. In the second patient, contrast medium was injected in spite of the fact that peripheral blood containing marrow elements could not possibly have been aspirated from the needle placed in the epidural space. As has been stated earlier in the paper, only strict adherence to the absolute rule *never to inject any substance unless peripheral blood containing marrow particles can be aspirated* will avoid faulty intraosseous venograms. Experience, however, has repeatedly demonstrated that a certain number of technical errors must generally be anticipated in any program concerned with resident training.

The technical failure following myelography performed on another service was due to intravasation of Pantopaque into the epidural, lumbar, and iliac veins as well as the inferior vena cava (Fig. 15). We refer to the literature for a more detailed discussion of this complication (47) which, in contradistinction to the epidural extravasation of a water-soluble substance such as Hypaque, may not always be without sequels. In the case included here, intravasation of Pantopaque was fortunately inconsequential.

DISCUSSION

Myelography with contrast media was introduced in 1922 by Sicard and Forestier (19) as an aid in the localization of spinal-cord tumors. These authors replaced a small volume of spinal fluid with iodized poppy-seed oil (Lipiodol). Mixter and Ayer (20) in 1935 demonstrated the value of this method in the diagnosis of lumbar disk protrusion or rupture. In 1942, ethyl-



Fig. 15. Myelogram with intravasation of Pantopaque into lumbar and iliac veins and inferior vena cava. Myelogram not diagnostic due to technical failure.

phenylundecylate (Pantopaque), a less viscous contrast medium, with the additional advantage of being absorbed in a variable but usually regular manner from the spinal subarachnoid space, replaced Lipiodol (1, 21, 22). Since then, Pantopaque has been used with increasing frequency, in greater amounts (23-25), and in recent years also in the diagnosis of lesions involving the aqueduct and the contents of the posterior fossa (4, 7, 26, 27).

Although the great diagnostic value of Pantopaque myelography and ventriculography is undeniable, certain disadvantages and limitations in its use have be-

TABLE III: RADICULITIS SURGICALLY NOT CONFIRMED OR OF UNKNOWN ORIGIN

Clinical	Venographic	Findings Myelographic	Operative	Comments
<i>Suspected Disk Protrusions</i>				
1. Radiculitis S1, Rt.	Block L5-S1, Lt. and L4-L5, Rt.	None	None	Improved on conservative therapy
2. Radiculitis S1, Lt. > Rt.	Block L5-S1, bilateral	Filling defect, L5-S1	None	Improved on conservative therapy
3. Radiculitis S1, Lt.	Normal	Normal	None	Improved on conservative therapy
4. Radiculitis S1, Rt.	Block L5-S1, Rt.	None	None	Improved on conservative therapy (Previous removal D.P. L4-L5, Rt.)
5. Radiculitis S1, Lt.	Technical failure	None	None	Improved on conservative therapy
6. Radiculitis L5, Lt.	Block L4-L5, bilateral	None	None	Improved on conservative therapy
7. Radiculitis L5, Lt.	Deviation to Rt., L4-L5	Normal	None	Improved on conservative therapy
8. Radiculitis L5, Rt.	Block L4-L5, Rt.	None	None	Improved on conservative therapy
9. Radiculitis L5, Rt. > Lt.	Block L4-L5, Rt. > Lt.	None	None	Improved on conservative therapy
10. Radiculitis L5 and S1, Lt.	Normal	Not diagnostic	None	Improved on conservative therapy
11. Radiculitis L5, bilateral and S1, Lt.	Block L4-L5, bilateral	None	None	Improved on conservative therapy
<i>Suspected Disk Protrusions in Patients with Psychiatric Symptoms</i>				
12. Radiculitis L5, Rt. and S1, Lt.	Normal	None	None	
13. Radiculitis L5, Lt.	Block, L4-L5, bilateral	Not diagnostic	None	
14. Radiculitis S1, Lt.	Deviation, L5-S1, Lt.	None	None	
15. Radiculitis S1, Lt.	Normal	Normal	None	
16. Radiculitis L5, Rt.	Normal	Normal	None	
<i>Radiculitis or Low Back Symptoms of Miscellaneous Origin</i>				
17. Radiculitis L5, Lt.	Thinning, lateral deviation and widening L4-L5, Lt.	Suggestive of D.P. at L3-L4, Lt.	Osteoarthritic ridge L4-L5	
18. Paget's disease and osteoarthritis, lumbar	Normal	None	None	
19. Radiculitis L5, Rt. and S1, bilateral	Block L5-S1, bilateral	None	No D.P. at L4-L5 and L5-S1. Ligamentum flavum abnormal and adherent with compression of dural sac	Patient asymptomatic postoperatively. Pathology: Ligamentum flavum showed loss of elastic fibers with replacement by material of undetermined nature
20. Radiculitis L1 and L2, Rt. (cauda equina tumor)	Normal	Technical failure (intravasation)	None	
21. Tuberculosis of vertebrae L2, L3, L4, L5	Filling defect, anterior epidural plexus L5-S1. Decreased filling, epidural plexus L4-S1, Lt.	Anterior filling defect	Arthrodesis L4 through S1	

come apparent. Several critical reports of clinical studies together with experimental observations (28-37) have indicated adverse reactions to Pantopaque on the part of the leptomeninges and neural structures, with resultant meningitis, radiculitis, cyst formation, and adhesive

arachnoiditis in the spinal canal or in the basal cisterns (Fig. 14), with occasional involvement of cranial nerves and even development of obstructive hydrocephalus. In 2 instances, death was attributed to Pantopaque myelography (33, 35). Ileus has also been mentioned as an indirect

TABLE IIIA: SUMMARY OF RESULTS IN PATIENTS WITH RADICULITIS OR LOW BACK SYMPTOMS OF UNVERIFIED OR MISCELLANEOUS ORIGIN

	No. of Procedures	Consistent Positive Findings	Level Correct; No Lateralization	Suggestive Positive Findings	Technical Failure	Normal	Not Diagnostic
Suspected disk protrusion at L5-S1	5	2	1	..	1	1	..
Venogram	2	..	1	..	..	1	..
Myelogram							
Suspected disk protrusion at L4-L5	6	5	..	..	..	1	..
Venogram	2	..	..	..	..	1	1
Myelogram							
Suspected disk protrusion in patients with psychiatric problems	5	2	..	..	..	3	1
Venogram	3	..	..	..	..	2	..
Myelogram							
Radiculitis or low back symptoms of miscellaneous origin	5	3	..	..	1	2	..
Venogram	3	2	..	..	..	..
Myelogram							
TOTAL	21	12	1	..	1	7	2
Venogram	10	2	1	..	1	4	2
Myelogram							

sequel. Davies (36) concluded that "the proportion of severe symptoms could not be ignored and show once more the necessity for restraint in employing this admittedly valuable procedure." Similar experiences have been previously reported with the use of iodized oil, Lipiodol (38, 46). Pantopaque intravasation (embolization) during myelography, with occasional intrathoracic distress, has been described in 6 cases, although, as Todd and Gardner pointed out, the actual incidence may be greater (47). This complication was observed in 1 of our cases (Fig. 15).

In view of these adverse reactions, Pantopaque myelography has been employed by most medical and surgical neurologists, as well as orthopedic surgeons, mainly as a preoperative diagnostic adjunct in the corroboration of the clinical diagnosis and for precise localization. Caution has been generally exercised in its use as a screening method in doubtful cases, in patients who may possibly respond to conservative therapy, and particularly in persons with emotional or neurotic disturbances and in those classified as malingerers or psychoneurotic failures. Furthermore, as DeJong pointed out, myelography is contraindicated in the presence of infection of the nervous tissues or meninges or if there is

roentgen evidence of a destructive lesion, compression of the vertebral bodies, or Pott's disease (48).

Aside from its adverse effects on meningeal and neural structures, myelography has been criticized as to its diagnostic accuracy, among others by Maltby and Pendergrass (49). Scoville, Moretz, and Hankins (50) in a critical analysis labeled previous statistics with a reported accuracy of 92 to 93 per cent as erroneous, since these were based on positive myelograms only. When myelography was used as the sole diagnostic criterion in lumbar disk lesions, the error was in the neighborhood of 25 to 35 per cent in their experience. These authors cited the findings of Danelius and Turney, who arrived at similar figures. Taveras, in a recent personal communication, gave an estimate of the diagnostic errors in protrusions of the intervertebral disk at the L5-S1 interspace alone as amounting to 20 per cent in the material of the New York Neurological Institute (51). MacCarty and Lane, in an informative publication on the *Pitfalls in Myelography*, found a lower overall incidence of errors (52). Their 223 operative cases included herniated disks (81.2 per cent), tumors of the spinal cord, meninges, and extradural tissues (8.5 per cent), as

TABLE IV: CONGENITAL MALFORMATIONS, TUMORS, ADHESIVE ARACHNOIDITIS, AND RADIATION MYELITIS AND/OR RADICULOPATHY

Final Clinical Diagnosis	Venographic	Findings Myelographic	Operative
Congenital malformations			
Spondylolisthesis and spina bifida L2-L5	Block L5-S1, bilateral	Block, almost total, L5-S1	Compression of dural sac secondary to spondylolisthesis (decompressive laminectomy)
Spondylolisthesis	Posterior deviation of anterior epidural plexus L5-S1	Normal root sleeves, increased distance between vertebral bodies and column of medium	Defect in interarticular processes (decompressive laminectomy)
Symptomatic spina bifida S1	Block, L5-S1, bilateral	Inadequate filling of root sleeve S1, left. Lateral view not diagnostic	Spina bifida S1, no disk pathology
Intradural tumors			
Ependymoma, cauda equina L2-L4 arising from filum terminale	Filling defect outlining lesion at L2-L4	Biconcave filling defect L2, with partial block	Ependymoma, L2-L4 (total removal)
Glioma C6-T1	Cervical injection. Block from C6 downward, bilateral	Biconcave partial block at C7	Intramedullary glioma C4-C7
Adhesive arachnoiditis	Normal	Total block L1, streaky appearance of medium	Adhesive arachnoiditis
Adhesive arachnoiditis	Normal	Total block L1-L2	None
Metastatic tumors			
Adenocarcinoma (lung) L2-L3 (osteolytic)	Total block, L2-L3	Narrowing of contrast column at L2	Epidural tumor (sub-total removal)
Epidermoid carcinoma (tongue) L2 (intertrabecular)	Block ascending lumbar vein right, L2-L3	Normal (conventional films normal)	None
Anaplastic epidermoid carcinoma L3-L5 (osteolytic)	Total block L5	Total block at L4	Epidural tumor L3-L5 invading dura at L4
Anaplastic carcinoma, (parotis) (intertrabecular) and disk protrusion at L4-L5	Total block at L3	Indicative only of disk protrusion at L4-L5	Disk protrusion L4-L5. Biopsy of spinous process of L3 showed anaplastic carcinoma
Anaplastic carcinoma, T9-T12 with paravertebral mass, Rt. (osteolytic)	Total block T11, lateral deviation of azygos vein at T12	Normal	Biopsy of paravertebral mass showed anaplastic carcinoma
Papillary adenocarcinoma (renal) T12-L3 (osteolytic) and T1	Total block, L3	Cisternal myelogram showed a block at T1, partial T11 total. Lumbar myelogram filling defect L3-L1, block T12-L1	Epidural tumor T12-L3
Radiation myelitis and/or radiculopathy L1-S1	Total block L5-S1	Normal	Avascularity of bone and epidural space. No evidence of tumor

well as miscellaneous conditions (10.1 per cent). They noted that in the diagnosis of 181 cases of herniated disk, of which 88 per cent occurred at the L4-L5 and L5-S1 levels, myelography was correct in 89.3 per cent, whereas the clinical diagnosis was corroborated in only 61.3 per cent. Diagnostic errors were attributed to inadequate amount of Pantopaque, faulty technic of injection, vertebral anomalies, normal variation in the size and shape of the subarachnoid space, and changes due to previous procedures. The most frequent myelographic error oc-

curred in lumbar disk lesions at the L5-S1 interspace, due to considerable tapering and narrowing of the dural cul-de-sac. This normal variant was held responsible for a large space between the anterior aspect of the Pantopaque column and the disk protrusion, frequently wide enough to conceal a herniation of considerable size.

The cited complications and limitations of myelography, mainly dependent on the deliberate introduction of a potentially irritating substance into the subarachnoid space through a lumbar puncture needle, are not encountered in the use of ver-

TABLE IVA: SUMMARY OF RESULTS IN PATIENTS WITH CONGENITAL MALFORMATIONS, TUMORS, ARACHNOIDITIS, AND RADIATION MYELITIS

	No. of Proce- dures	Correct	Sug- ges- tive	Normal
Congenital mal- formations				
Venogram	3	3	..	..
Myelogram	3	2	1	..
Intradermal tumors				
Venogram	2	2	..	..
Myelogram	2	2	..	..
Adhesive arach- noiditis				
Venogram	2	..	..	2
Myelogram	2	2	..	..
Metastatic tumors				
Venogram	6	6	..	..
Myelogram	6	3	..	3
Radiation myelitis				
Venogram	1	1	..	..
Myelogram	1	..	..	1
TOTAL				
Venogram	14	12	..	2
Myelogram	14	9	1	4

tebral venography. The injection of contrast medium into a spinous process allows a short-lasting opacification of the epidural and intervertebral veins without leaving any trace of radiopaque material and without causing a persisting change in the pressure relationship within the subarachnoid space. The aggravation of symptoms in the presence of an intraspinal tumor, occasionally observed following lumbar puncture and/or myelography, will also be avoided. Vertebral venography could, therefore, be employed repeatedly as a screening procedure and even in non-hospitalized patients.

In contrast to the vast experience gained with the use of myelography, vertebral venography has attracted attention only in recent years. Batson (1940) stimulated clinical interest in the possible role of the vertebral venous plexuses in the spread of metastases and infection (10). Anderson (1951) was the first to demonstrate the vertebral plexus by injection of Diodrast into a femoral vein under simultaneous abdominal compression (11). Fischgold *et al.* proved the feasibility of opacification of the vertebral plexuses and azygous veins by the injection of contrast medium into a spinous process of a lower thoracic verte-

bra (53). The diagnostic value of vertebral venography, however, was not studied until 1955, when two groups of investigators (13, 54) reported their experiences with venography in the diagnosis of lumbar disk herniations, Hodgkin's disease, and metastatic tumors of the lumbar and lower thoracic spine in a small series of cases. Vertebral venography, *via* injection into either femoral veins or spinous processes, demonstrated in most instances obstruction of the internal venous plexus at the site of the metastatic lesions. In 3 cases of lumbar disk protrusions, Helander and Lindblom noted that the venous plexus behind the herniated disk was not contrast-filled (54). Lessmann *et al.* (13) obtained normal intraosseous venograms in 4 cases of traumatic vertebral lesions and questionable degeneration of the intervertebral disk. These authors, however, did not employ abdominal compression as used in our study. Nathan and Blum (55), in a recent publication, were rather discouraged by the use of vertebral venography *via* the femoral veins. In 4 cases of advanced vertebral metastases, the vertebral venous system appeared to be unaffected. They likewise doubted the value of venography in the diagnosis of lumbar disk protrusion, particularly the smaller ones, and felt that myelography is more certain and more easily applicable for the demonstration of this condition. Although they admitted that the diagnosis of a spinal cord tumor may be possible by venography, no advantage was seen in comparison with myelography.

In evaluating the technical aspects and the diagnostic potentialities of intraosseous venography in our group of 68 patients we have found the method of value in a variety of conditions involving the lumbar and in a few instances the lower thoracic spine and their adjacent structures. Whether venography will be of consistent help in lesions of the upper thoracic and cervical spine, only further experience will prove.

The technic of intraosseous venography is not difficult, although some technical

failures will be encountered, particularly in the beginning. Inconsequential spillage of contrast medium into the soft tissues surrounding the spinous process selected for injection may occur. This is particularly true at the level of S1 or S2 if the punctured spinous process is very narrow, thus not allowing the proper intramedullar placement of the needle. Extravasation of contrast medium into the epidural space has been observed only twice. In our experience, however, no immediate or late complications have been noted. The procedure is usually well tolerated, although some momentary sensation of pronounced local pressure may be experienced during the injection. Longer lasting pain usually denotes extravasation. Many patients stated their preference for venography in comparison to the discomfort associated with myelography. Others, however, preferred the latter procedure.

The interpretation of the venograms offers some problems to the uninitiated but, after relatively little experience, proper identification of the various venous structures and their pathological alterations becomes possible. It is true that the myelographic diagnosis of a lesion such as a protrusion of a lumbar disk with its focal derangement of the opaque column or root sleeves is more obvious and simpler. Due to the complexity of the venous structures, the recognition of the normal and abnormal patterns of the vertebral plexuses presents some difficulties, but these can be overcome with growing experience.

During the comparative evaluation of myelography and vertebral venography in the diagnosis of specific lesions, it became apparent that the two methods have different potentialities in the sense that one will not simply replace the other. In certain conditions myelography proved to be preferable to venography and *vice versa*. In another set of circumstances vertebral venography assumed the function of a supplementary study, adding valuable diagnostic data. Furthermore, if myelography is contraindicated or in-

advisable, or if the lumbar puncture is traumatic or does not yield spinal fluid, as in cases of large cauda equina tumors, vertebral venography can be substituted without delay.

In summarizing our experience with 68 patients with a variety of lesions, we feel that in the diagnosis of lumbar disk protrusions the reliability of vertebral venography was of equal range in comparison to myelography. Venography can, therefore, replace myelography in most instances. Only under conditions where the venographic findings do not corroborate the clinical diagnosis should there be resort to myelography. We found venography particularly useful as a screening method in doubtful cases and in instances of a first attack of low back pain with or without radiculitis in which conservative therapy appeared advisable. Where the patient displays neurotic or even psychotic symptoms, venography can be performed without hesitation, whereas there may be objections to the use of myelography under these circumstances.

In conditions which may simulate the lumbar disk syndrome, such as spondylolisthesis (56, 57) or painful spina bifida (58, 59), venography was of equal accuracy compared to myelography, being even superior in the case of symptomatic spina bifida occulta of the first and second sacral segment. It appears reasonable to assume that in other entities simulating lumbar disk protrusions, like hypertrophic osteosclerosis and epidural varicosities, venography may be particularly useful. Schnitker and Curtzwiler (60) stressed the marked engorgement of the epidural veins in the former condition; others have described the dilatation of the veins in "epidural varicosities" (61, 62), which may produce a myelographic defect characteristic of disk protrusion (63).

Although our experience with intradural neoplasms is limited, an ependymoma of the cauda equina, as well as a glioma of the lower cervical spinal cord, were well outlined on the venogram. In 2 instances of spinal adhesive arachnoiditis in which

the myelogram indicated a total block, the normal appearance of the venogram excluded the presence of a tumor, which had to be considered in the differential diagnosis.

In the group of metastatic lesions of the spine, especially in cases of "hidden metastases," venography appeared to be superior to myelography. The typical venographic pattern of total block was present in all proved cases of metastatic disease of the spine, even when conventional roentgenograms, tomograms, or myelograms had failed to establish the diagnosis. The discrepancies of our results in spinal metastatic disease as compared to the negative finding of Nathan and Blum, who employed vertebral venography by femoral injection, can perhaps be attributed to the difference in technic. In this connection, it is of interest that Lessmann and Perese (64), in a recent publication which appeared after the completion of our study, reached conclusions similar to ours in the evaluation of intraosseous vertebral venography.

Another observation in a case of seminoma with apparent radiation radiculopathy of the cauda equina and/or myelitis of the conus medullaris was rather interesting. The marked fibrosis of the lumbar spine and the avascularity of the lumbar vertebrae and epidural fat layer were manifested in the vertebral venogram by a pattern similar to that encountered in metastatic vertebral disease. Repeated myelograms had previously shown normal findings, and the absence of metastatic tumor in vertebral body, arches, and intraspinal space was proved by trocar biopsy and exploratory lumbar laminectomy. The latter procedure at the same time verified the fibrotic changes and rather striking avascularity, both evident on histologic examination. The venogram thus confirmed observations of the vascular changes induced by radiation, as reported by Hicks (65) and Warren (66). On the other hand, extensive irradiation of metastatic disease may invalidate the results of vertebral venography in the

detection of metastatic involvement of the vertebral column and spinal canal.

Although our observations are limited in certain categories of lesions, it is our present feeling that vertebral venography is a diagnostic method of great value which in many instances can replace myelography. We believe that venography should be employed as the initial study in the corroboration of the clinical diagnosis. If the findings strongly support the clinical impression, myelography can be avoided. We have embarked on such a program with consistently reliable results to date.

SUMMARY

1. A comparative study of intraosseous epidural venography and myelography in 68 patients with a variety of lesions of the lumbosacral spine (disk protrusion, congenital malformation, adhesive arachnoiditis, radiation myelitis and/or radiculopathy, primary and metastatic tumors) is presented. Venography was performed in all and myelography in 51 patients, with surgical confirmation of the diagnosis in 48 instances.

2. The anatomic and physiologic aspects necessary for the understanding of the venographic technic and diagnosis are discussed. The technic of intraosseous epidural venography as employed by the authors is described.

3. The literature on myelography and vertebral venography is reviewed, with particular emphasis on complications and diagnostic accuracy.

4. A statistical comparison of myelography and venography, supplemented by clinical and surgical data, is tabulated. The various representative venographic patterns are described in detail.

5. In comparing the two diagnostic methods, the conclusion is reached that venography can replace myelography in most instances.

6. Vertebral venography should be employed as the initial contrast study whenever possible. Myelography can always be resorted to, if necessary.

ADDENDUM

Since submission of this communication, 40 additional patients, including several with metastatic neoplasms of the dorsal spine, have been evaluated with intraosseous vertebral venography. The collected observations have consistently lent further support to the conclusions expressed above, particularly with reference to the superiority of venography in the diagnosis of vertebral metastases and disk protrusions of the L5-S1 interspace. It became evident that venography was reliable in detecting both the location and the extent of metastatic lesions of the thoracic spine.

VA Hospital
Bronx 68, N. Y.

REFERENCES

- PEACHER, W. G., AND ROBERTSON, R. C. L.: Pantopaque Myelography: Results, Comparison of Contrast Media, and Spinal Fluid Reaction. *J. Neurosurg.* **2**: 220-231, May 1945.
- SPURLING, R. G.: Lesions of the Cervical Intervertebral Disc. Springfield, Ill., Charles C Thomas, 1956, pp. 72-73.
- BERING, E. A., JR.: Notes on the Retention of Pantopaque in the Subarachnoid Space. *Am. J. Surg.* **80**: 455-458, October 1950.
- BULL, J. W. D.: Positive Contrast Ventriculography. *Acta radiol.* **34**: 253-268, October-November 1950.
- SHIPP, F. L.: Technique and Value of Myelography. *J.A.M.A.* **151**: 185-188, Jan. 17, 1953.
- MALIS, L. I.: The Myelographic Examination of the Foramen Magnum. *Radiology* **70**: 196-221, February 1958.
- HORWITZ, N. H.: Positive Contrast Ventriculography—A Critical Evaluation. *J. Neurosurg.* **13**: 388-399, July 1956.
- SCHOBINGER, R., AND LESSMANN, F. P.: A New Approach Allowing the Roentgenologic Demonstration of the Cervical Vertebral Venous Plexi. *Exper. Med. & Surg.* **15**: 289-299, 1957.
- SCHOBINGER, R.: Intra-osseous Venography of the Atlas. *Angiology* **8**: 428-432, October 1957.
- BATSON, O. V.: Function of the Vertebral Veins and Their Role in the Spread of Metastases. *Ann. Surg.* **112**: 138-149, July 1940.
- ANDERSON, R. K.: Diodrast Studies of the Vertebral and Cranial Venous Systems to Show Their Probable Role in Cerebral Metastases. *J. Neurosurg.* **8**: 411-422, July 1951.
- SCHOBINGER, R.: Intra-osseous Venography. New York, Grune & Stratton, Inc., 1960.
- LESSMANN, F. P., SCHOBINGER VON SCHOWINER, R., AND LASSER, E. C.: Intra-Osseous Venography in Skeletal and Soft Tissue Abnormalities. *Acta radiol.* **44**: 397-409, November 1955.
- SCHOBINGER, R., AND LESSMANN, F. P.: Intraosseous Venography—Its Value to the Surgeon. *S. Forum* **7**: 459-463, 1957.
- SCHOBINGER, R.: L'artériographie et la phlébographie intramedullaire dans le diagnostic des tumeurs. *Méd. & Hyg. (Geneva)* **17**: 69-70, 1959.
- KRUEGER, E. G., AND SCHOBINGER, R.: Intraosseous Epidural Venography in the Diagnosis of Surgical Diseases of the Lumbar Spine. *S. Forum* **11**: 396-398, 1960.
- DYNES, J. B., AND SMEDAL, M. I.: Radiation Myelitis. *Am. J. Roentgenol.* **83**: 78-87, January 1960.
- FRIEDMAN, M.: Calculated Risks of Radiation Injury of Normal Tissue in the Treatment of Cancer of the Testis. [In] *Proc. 2nd National Cancer Conference*. New York, Am. Cancer Soc., 1954, pp. 390-400.
- SICARD, J. A., AND FORESTIER, J.: Méthode générale d'exploration radiologique par l'huile iodée (Lipiodol). *Bull. et mém. Soc. méd. d. hôp. de Paris* **46**: 463-469, March 17, 1922.
- MIXTER, W. J., AND AYER, J. B.: Herniation or Rupture of the Intervertebral Disc into the Spinal Canal; Report of 34 Cases. *New England J. Med.* **213**: 385-393, Aug. 29, 1935.
- RAMSEY, G. H., FRENCH, J. D., AND STRAIN, W. H.: Iodinated Organic Compounds as Contrast Media for Radiographic Diagnosis. IV. Pantopaque Myelography. *Radiology* **43**: 236-240, September 1944.
- WYATT, G. M., AND SPURLING, R. G.: Pantopaque: Notes on Absorption Following Myelography. *Surgery* **16**: 561-566, October 1944.
- MALIS, L., NEWMAN, C. M., AND WOLF, B. S.: Full-Column Technique in Lumbar Disk Myelography. *Radiology* **60**: 18-27, January 1953.
- KVERNLAND, B. N., GREWE, R. V., WOOLLEY, I. M., AND LEE, J. R.: Upright Large Volume Dynamic Myelography. *Radiology* **72**: 562-568, April 1959.
- HAFT, H., WEINSTEIN, C. E., AND KRUEGER, E. G.: Larger Volume Pantopaque Lumbar Myelography. *Radiology* **74**: 605-610, April 1960.
- MONES, R., AND WERMAN, R.: Pantopaque Myelencephalography. *Radiology* **72**: 803-809, June 1959.
- WILSON, M., AND SNODGRASS, S. R.: Positive Contrast Ventriculography. *Radiology* **72**: 810-815, June 1959.
- SCHNITKER, M. T., AND BOOTH, G. T.: Pantopaque Myelography for Protruded Disks of the Lumbar Spine. *Radiology* **45**: 370-376, October 1945.
- TARLOV, I. M.: Pantopaque Meningitis Disclosed at Operation. *J.A.M.A.* **129**: 1014-1016, Dec. 8, 1945.
- FORD, L. T., AND KEY, J. A.: An Evaluation of Myelography in the Diagnosis of Intervertebral-Disc Lesions in the Low Back. *J. Bone & Joint Surg.* **32-A**: 257-266, April 1950.
- LUCE, J. C., LEITH, W., AND BURRAGE, W. S.: Pantopaque Meningitis Due to Hypersensitivity. *Radiology* **57**: 878-881, December 1951.
- SCHURR, P. H., MC LAURIN, R. L., AND INGRAM, F. D.: Experimental Studies on Circulation of Cerebrospinal Fluid and Methods of Producing Communicating Hydrocephalus in the Dog. *J. Neurosurg.* **10**: 515-525, September 1953.
- ERICKSON, T. C., AND VAN BAAREN, H. J.: Late Meningeal Reaction to Ethyl Iodophenylundecylenate Used in Myelography; Report of a Case that Terminated Fatally. *J.A.M.A.* **153**: 636-639, Oct. 17, 1953.
- HURTEAU, E. F., BAIRD, W. C., AND SINCLAIR, E.: Arachnoiditis Following the Use of Iodized Oil. *J. Bone & Joint Surg.* **36-A**: 393-400, April 1954.
- REINHARDT, K.: Aktuelle Probleme in der Kontrastmitteluntersuchung des Wirbelkanals. *Fortschr. a. d. Geb. d. Röntgenstrahlen* **83**: 809-819, December 1955.
- DAVIES, F. L.: Effect of Unabsorbed Radiographic Contrast Media on the Central Nervous System. *Lancet* **2**: 747-748, Oct. 13, 1956.
- TAREN, J. A.: Unusual Complication Following Pantopaque Myelography. *J. Neurosurg.* **17**: 323-326, March 1960.
- ALBRECHT, K.: Die röntgenologische Darstellung von Rückenmarks—Tumoren durch Iodipin.

January
Radiation
of Cancer
er Con-
954, pp.
Méthode
le iodée
de Paris
Formation
le Spinal
J. Med.
STRAIN,
Contrast
topaque
September
Pantop-
graphy.
B. S.:
graphy.
OLLEY,
dynamic
59.
JEGER,
Myelog-
paque
June
sitive
815,
Pantop-
Lumbar
Dis-
1016,
ation
bral-
Burg.
S.:
vity.
GRA-
on
com-
urg.
Late
late
mi-
53.
AIR,
Oil.
der
ort-
19,
jou-
m.
ng
26,
ar-
in.

Zentralbl. f. d. Ges. Neurol. u. Psychiat. **41**: 921-925, 1925.
 39. PEIPER, H.: Die Myelographie im Dienste der Diagnostik von Erkrankungen des Rückenmarks. *Ergebn. d. med. Strahlenforsch.* **2**: 107-195, 1926.
 40. WARTENBERG, R.: Beitrag zur Encephalographie und Myelographie. *Arch. f. Psychiat.* **77**: 307-331, 1926.
 41. ODIN, M., AND RUNSTRÖM, G.: Iodized Oils as Aid to Diagnosis of Lesions of the Spinal Cord and Contribution to Knowledge of Adhesive Circumscribed Meningitis. *Acta radiol. Suppl.* **7**, 1928.
 42. RODRIGUEZ DE MATA, T.: Un caso de amaurosis total y transitoria consecutiva a una inyección intraracémica de Lipiodol. *Actas Soc. de cir. de Madrid* **2**: 165-168, April-June 1933.
 43. SIEBNER, M.: Pachymeningitis cervicalis hypertrophica und akute Schädigung durch Myelographie. *Chirurg* **7**: 177-180, March 15, 1935.
 44. MARCOVICH, A. W., WALKER, A. E., AND JESSICO, C. M.: The Immediate and Late Effects of the Intrathecal Injection of Iodized Oil. *J.A.M.A.* **116**: 2247-2254, May 17, 1941.
 45. CRAIG, W. M., AND WALSH, M. N.: Neuro-Anatomical and Physiological Aspects and Significance of Sciatica. *J. Bone & Joint Surg.* **23**: 417-434, April 1941.
 46. BUCY, P. C., AND SPEIGEL, I. J.: An Unusual Complication of the Intraspinal Use of Iodized Oil. *J.A.M.A.* **122**: 367-369, June 5, 1943.
 47. TODD, E. M., AND GARDNER, W. J.: Pantopaque Intravasation (Embolization) During Myelography. *J. Neurosurg.* **14**: 230-234, March 1957.
 48. DEJONG, R. N.: The Neurologic Examination: Incorporating the Fundamentals of Neuroanatomy and Neurophysiology. New York, Paul B. Hoeber, Inc., 1950, p. 1014.
 49. MALTBY, G. L., AND PENDERGRASS, R. C.: Pantopaque Myelography: Diagnostic Errors and Review of Cases. *Radiology* **47**: 35-46, July 1946.
 50. SCOVILLE, W. B., MORETZ, W. H., AND HANKINS, W. D.: Discrepancies in Myelography: Statistical Survey of 200 Operative Cases Undergoing Pantopaque Myelography. *Surg., Gynec. & Obst.* **86**: 559-564, May 1948.
 51. TAVERAS, J.: Personal communication.
 52. MACCARTY, W. C., JR., AND LANE, F. W., JR.: Pitfalls of Myelography. *Radiology* **65**: 663-670, November 1955.
 53. FISCHGOLD, H., ADAM, H., ECOIFFIER, J., AND PIEQUET, J.: Opacification des plexus rachidiens et des veines azygos par voie osseuse. *J. radiol. et électrol.* **33**: 37, 1952.
 54. HELANDER, C. G., AND LINDBOM, Å.: Sacro-lumbar Venography. *Acta radiol.* **44**: 410-416, November 1955.
 55. NATHAN, M. H., AND BLUM, L.: Evaluation of Vertebral Venography. *Am. J. Roentgenol.* **83**: 1027-1033, June 1960.
 56. WOOLSEY, R. D.: The Mechanism of Neurological Symptoms and Signs in Spondylolisthesis at the Fifth Lumbar, First Sacral Level. *J. Neurosurg.* **11**: 67-76, January 1954.
 57. GILL, G. G., MANNING, J. G., AND WHITE, H. L.: Surgical Treatment of Spondylolisthesis without Spine Fusion; Excision of Loose Lamina with Decompression of Nerve Roots. *J. Bone & Joint Surg.* **37-A**: 493-520, June 1955.
 58. JELLSMA, F., AND PLOETNER, E. J.: Painful Spina Bifida Occulta with Review of the Literature. *J. Neurosurg.* **10**: 19-27, January 1953.
 59. GILL, G. G., AND WHITE, H. L.: Mechanisms of Nerve-Root Compression and Irritation in Backache. Surgical Decompression in Intervertebral Disk Conditions—Spondylolisthesis, Spina Bifida Occulta, and Transitional Lumbar Vertebra. *Clin. Orthop.*, No. 5, 1955, pp. 66-81.
 60. SCHNITKER, M. T., AND CURTZWILER, F. C.: Hypertrophic Osteosclerosis (Bony Spur) of the Lumbar Spine Producing the Syndrome of Protruded Intervertebral Disc with Sciatic Pain. *J. Neurosurg.* **14**: 121-128, March 1957.
 61. GLOOR, P., WORINGER, E., SCHNEIDER, J., AND BROGLY, G.: Lombosciatiques par anomalies vasculaires épidiurales. *Schweiz. med. Wochenschr.* **82**: 537-542, May 17, 1952.
 62. SERFLING, H. J., AND PARNITZKE, K. H.: Die epidurale Varicosis spinalis als Ursache von Wurzelsyndromen. *Ztschr. f. Orthop.* **89**: 437-457, 1958.
 63. EPSTEIN, B. S.: Low Back Pain Associated with Varices of the Epidural Veins Simulating Herniation of the Nucleus Pulsus. *Am. J. Roentgenol.* **57**: 736-740, June 1947.
 64. LESSMANN, F. P., AND PERESE, D. M.: Intraosseous Vertebral Plexus Venography. *Neurochirurgia* **2**: 175-189, February 1960.
 65. HICKS, S. P.: Effects of Ionizing Radiation on Adult and Embryonic Nervous System. *A. Res. Nerv. & Ment. Dis., Proc.* (1952) **32**: 439-462, 1953.
 66. WARREN, S.: Effects of Radiation on Normal Tissues. *Arch. Path.* **35**: 121-139, January 1943.

SUMARIO IN INTERLINGUA

Comparation de Intraossee Venographia Vertebral con Myelographia a Pantopaque in le Diagnose de Morbos Chirurgic del Spina Lumbar e del Radices Nerval

Es presentate un studio comparative de intraossee venographia epidural con myelographia, effectuate in 68 patientes con un varietate de lesiones del spina lumbosacral—protrusion de disco, malformation congenite (incluse spondylolisthesis e dolorose spina bifida occulte), arachnoiditis adhesive, myelitis de radiation e/o radiculopathia, e primari o metastatic tumor. Venographia esseva execute in omnes, myelographia in 51, con confirmation

chirurgic in 48. Representative e comparative myelogrammas e venogrammas es reproducite. Le constataciones, insimul con datos clinic e chirurgic, es tabulate.

Un processo spinose—preferibilmente de un vertebra de suto in direction caudal ab illo del suspecte anormalitate—es identificate in un pellicula exploratori, e un agulha de medulla ossee es introducite sub anesthesia local. Sanguine peripheric continent particulas de medulla ossee debe

esser aspirete liberemente ante que le substantia de contrasto es injicie. Post que il ha essite verificate que le placiamento del agulia es correcte, 2 o 3 cm³ de procaina es introducite intra le cavitate del medulla, sequite (al media) per 25 cm³ de Hypaque de 50 pro cento. Un sol pellicula exponite durante le injection del ultime 2 o 3 cm³ va fornir le desirata information. Compression abdominal es empleate routinarimente durante le integre manovra, como in urographia. A generalmente parlar, un projection postero-anterior es le plus informative, sed expositiones lateral e

oblique pote esser obtenite pro objectivos de supplementation.

Sub conditiones normal, le substantia de contrasto escappa promptemente ab le cavitate medullari del injicie osso ad in le externe e interne plexos venose.

Es concludite que venographia vertebral es un metodo diagnostic de grande valor que es capace a reimplaciar myelographia in multe casos. Illo deberea esser empleate como studio initial in le corroboration del diagnose clinic. Si su resultado supporta fortemente le impression clinic, myelographia pote esser evitata.



Angi

IN THE
in the
disease
advances
omy and
culation
for the
orders.
has been
who say
tion in
suming
of the
icance
one acc
precise
structio
region.
multip
be inv
circle
the ne
of the
the bl
factors
and a
The
Fisher
Hutch
tion t
produ
ciency
occlus
that
As a
the v
tive
acco
cereb
facto
thos
have
et al

Angiographic Investigation of Cerebrovascular Insufficiency¹

HILLIER L. BAKER, JR., M.D.

IN THE past decade, an increased interest in the problems of occlusive vascular disease of the brain has led to important advances in knowledge of the basic anatomy and physiology of the cerebral circulation, as well as to more precise methods for the diagnosis and treatment of its disorders. All aspects are interrelated, as has been recently pointed out by Wells (1), who says: "The factors affecting circulation in health and disease are multiple, assuming a complexity consonant with that of the organ affected. The clinical significance of this is apparent—no longer can one accept clinical evidence of a neurologic deficit which appears to arise within a precise area of the brain as evidence of obstruction of the end artery supplying that region. Only by consideration of the multiple factors which might conceivably be involved—possible variations in the circle of Willis, diseases of the vessels of the neck, effects of various positions, state of the systemic circulation, variations in the blood itself, as well as many other factors—can a rational mode of therapy and a comprehension of the dynamics of the observed disorders evolve."

The investigations of Hultquist (2), Fisher (3, 4), Samuel (5), Adams (6), and Hutchinson and Yates (7, 8) drew attention to the important part played in the production of cerebrovascular insufficiency and "strokes" by stenosing and occluding lesions of the arteries of the neck that carry the major cerebral circulation. As a sequel to these studies and because the vessels are easily accessible, reconstructive operations for such lesions have been accomplished in numerous patients with cerebrovascular disease, leading to satisfactory relief of symptoms in many. Among those extensively employing this method have been Rob and Wheeler (9), Bahnson *et al.* (10), De Bakey *et al.* (11-13), Gurd-

jian *et al.* (14, 15), Keirns and Whiteleather (16), Murphey and Miller (17), and Javid (18).

At the Mayo Clinic we have also been interested in the operative treatment of this condition and for the past two years have attempted an intensive neurologic, radiologic, and surgical evaluation of patients whose clinical signs and symptoms were believed to have resulted from cerebrovascular insufficiency. It was generally agreed that angiographic investigation should be undertaken prior to operation to determine the presence, number, location, and severity of stenosing and occluding lesions in the carotid and vertebral-basilar arterial systems. This enabled the neurologist to check his diagnostic acumen and the surgeon to plan his operative procedure or procedures intelligently, prior to their execution. The following is a résumé of our angiographic experiences in these two years.

DIAGNOSTIC CONSIDERATIONS

All patients included in this study were carefully screened and were thought to have had vascular disease involving the brain. On the basis of clinical appearance, they were divided into three main categories; namely, those with: (a) *incipient stroke*—brief, intermittent focal cerebral symptoms, with normal intervals between attacks; (b) *progressing stroke*—focal cerebral symptoms, seen to progress over a period of hours or a few days; (c) *completed stroke*—focal cerebral infarction the symptoms of which were not progressing, although improvement usually occurred without treatment.

Of 96 patients, 61 were deemed to have incipient strokes and 35 to have completed strokes. There were no progressing strokes, probably because most of our patients are ambulatory. Seventy-two were men and

¹ From the Section of Roentgenology, Mayo Clinic and Mayo Foundation, Rochester, Minn. Presented at the Forty-sixth Annual Meeting of the Radiological Society of North America, Cincinnati, Ohio, Dec. 4-9, 1960.

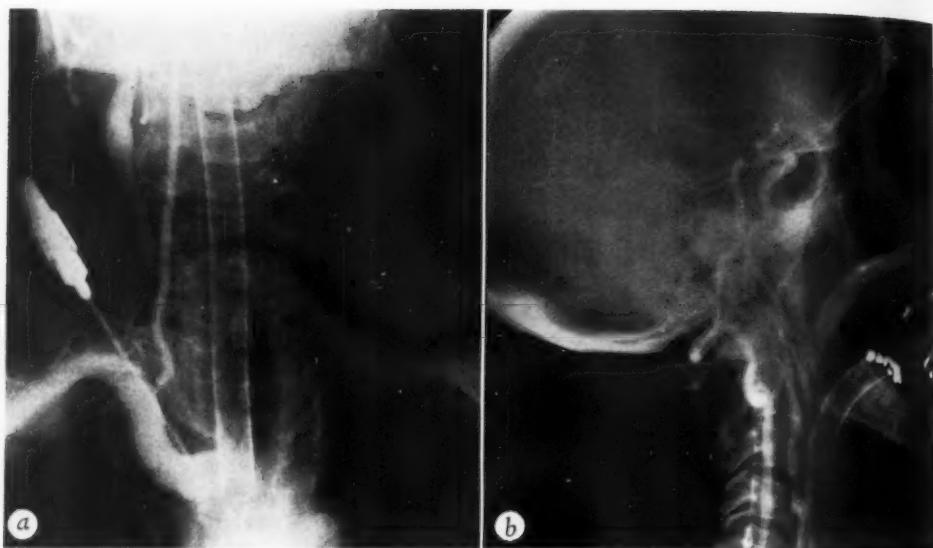


Fig. 1. *a*. Anteroposterior view of upper mediastinum and neck. Stenosis at origin of vertebral artery is evident. Changes at carotid bifurcation are questionable. *b*. Lateral view to show carotid bifurcation and intracranial vessels. Note ease with which changes at bifurcation can be observed.

24 were women, and most were in the fifth to seventh decades of life. Some clinical signs helpful in making the diagnosis of vascular disease, aside from an observed neurologic deficit, were bruits heard over the vessels in the upper mediastinum and neck, decreased pressure in the retinal artery of one or both eyes, and similar decreases of blood pressure in the arms. Observation of these signs did not preclude the need for angiography, however, as in their presence multiple lesions were often demonstrated.

ANGIOGRAPHIC CONSIDERATIONS

Many techniques have been employed for the introduction of contrast medium into the arteries in the neck that supply blood to the brain, including direct injection into the carotid, vertebral, or subclavian artery; retrograde injection into the brachial artery; intra-arterial catheterization; direct aortic puncture; and venous angiography. We have utilized all of these methods and have found that we can produce roentgenograms of excellent diagnostic quality more consistently by direct injection into the carotid and sub-

clavian arteries than by other means. Less medium is necessary, a minimum of complicated apparatus is required, and the examination can be accomplished with dispatch.

Ideally, all four arteries supplying blood to the brain should be depicted, but in practice complete angiography was accomplished in only 13 of our 96 cases. Bilateral subclavian injections show the left and right vertebral and the right carotid circulations. On the left it is necessary to make a separate injection into the common carotid artery. We often dispense with the left subclavian injection if the right vertebral artery is of adequate size and free of disease. We believe that in such a situation any lesion of the left vertebral artery is of questionable clinical significance and we are satisfied with visualization of three arteries. This was considered sufficient in 27 of our cases. In the remaining 56, the examination was terminated after the demonstration of severe stenosing or occluding lesions in one or two vessels. One hundred and fifty-four angiographic examinations of the 96 patients were made.

Roentgenograms are always obtained in both the anteroposterior and lateral projections. The anteroposterior view is for evaluation of the vessels in the upper mediastinum (Fig. 1, a), but we have found it difficult to assess changes at the carotid bifurcation in this projection even when the head is turned far to the side. The lateral view (Fig. 1, b) displays the carotid

PATHOLOGIC FINDINGS

Because of the rigid clinical selection, we were able to demonstrate abnormal changes in almost 80 per cent of our cases.

Thirty-four patients had arterial occlusions. In 4 the occlusions were multiple, involving both internal carotid arteries in 2, the left internal carotid and subclavian arteries in 1, and both subclavian arteries

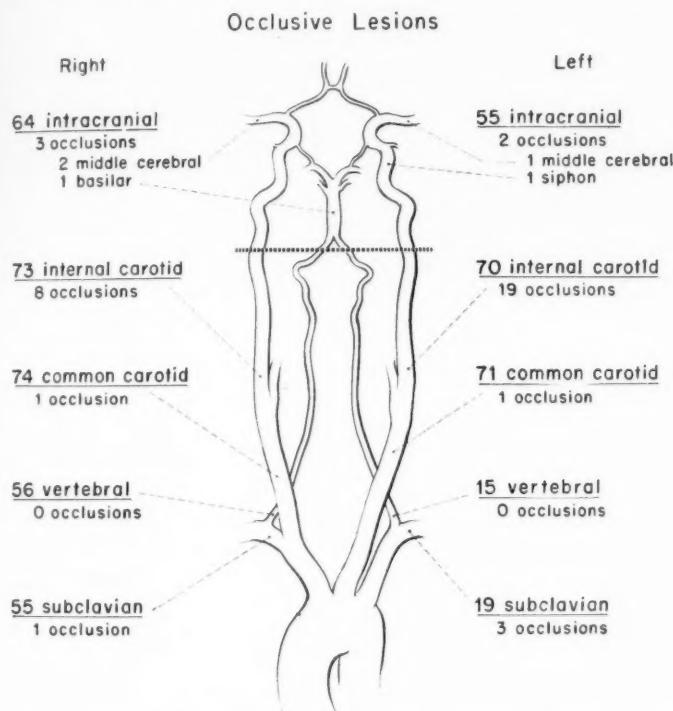


Fig. 2. Incidence and distribution of vascular occlusions observed in 154 angiograms.

bifurcation to best advantage, and, what is more important, the head is positioned in such a way that the intracranial structures may be visualized. In 16 of our patients the only abnormal changes found were inside the head, including a tumor and several aneurysms in addition to vascular stenoses and occlusions. Five other patients had major intracranial lesions in addition to vascular changes in the neck. To omit this portion of the examination, then, is an injustice to patients with presumed cerebrovascular disease.

in 1. The last-mentioned patient also had severe stenosis of both internal carotid arteries and the right common carotid artery. Six patients with occlusion of one internal carotid had, in addition, significant stenotic lesions in other locations, and one with an occluded left subclavian artery also had extensive other disease.

Atherosclerotic narrowing of the vessels was shown in 38 cases. In 9 of these, operative treatment was not possible because the observed changes were limited to the small intracranial vessels. In half of the

remaining patients multiple significant lesions could be demonstrated. The most common site of difficulty was the origin of the internal carotid artery. Figures 2 and 3 depict the types and sites of the lesions observed.

COMPLICATIONS

Cerebral arteriography entails the risk of producing neurologic deficit or, rarely,

arteriography in 68 cases of "stroke," and 20.6 per cent of the patients had an increase in hemiplegia or a decrease in the level of consciousness or died. Silverstein (20) had similar unfavorable results in 8.5 per cent of his patients. Both employed primarily puncture of the carotid artery. Others (21, 22) with different technics have had less difficulty. It would seem, therefore, that the incidence of complications

Stenotic and Other Lesions

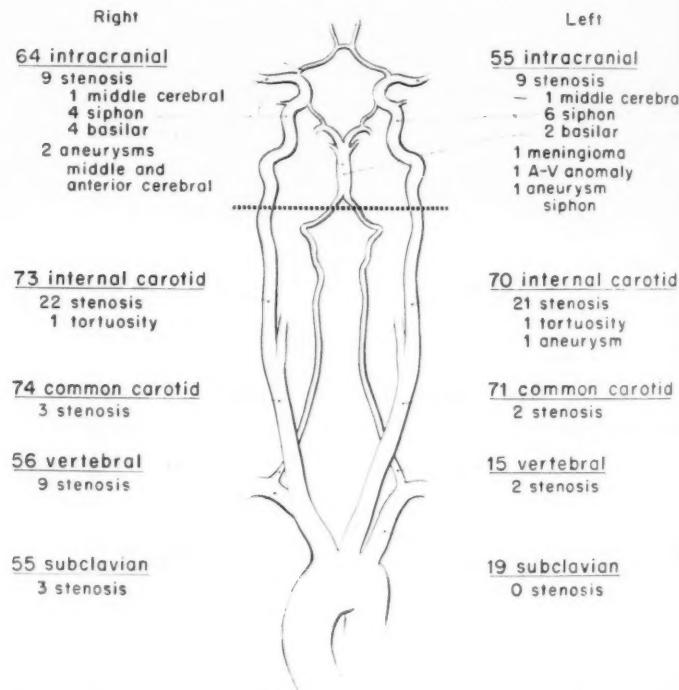


Fig. 3. Incidence and distribution of vascular stenotic lesions observed in 154 angiograms.

death. It is difficult to ascertain how often untoward neurologic symptoms are precipitated by arteriography in patients with cerebrovascular disease. Many reports have been published concerning the safety of the procedure, but most series contain many patients with lesions of other types, which makes application of the conclusions somewhat hazardous in the group of cases under consideration here.

McDowell and associates (19) performed

depends upon the mode of examination as well as on the state of the artery receiving the injection and possibly on the contrast medium employed.

Complications were observed in 13 (13.5 per cent) of our 96 patients. Pneumothorax resulted from an unsuccessful subclavian puncture in 1 case, and death due to cardiac failure occurred in another two weeks after examination. The remaining 11 complications consisted in the appear-

Fig. 4
b. Late
needle t
ance o
of one
persis
In all
logic
graph
All
sociat
artery
steno
these
6 pa
pepte
Thes
exclu
high
as th
sible
rotic
ture,
intra
com
cou

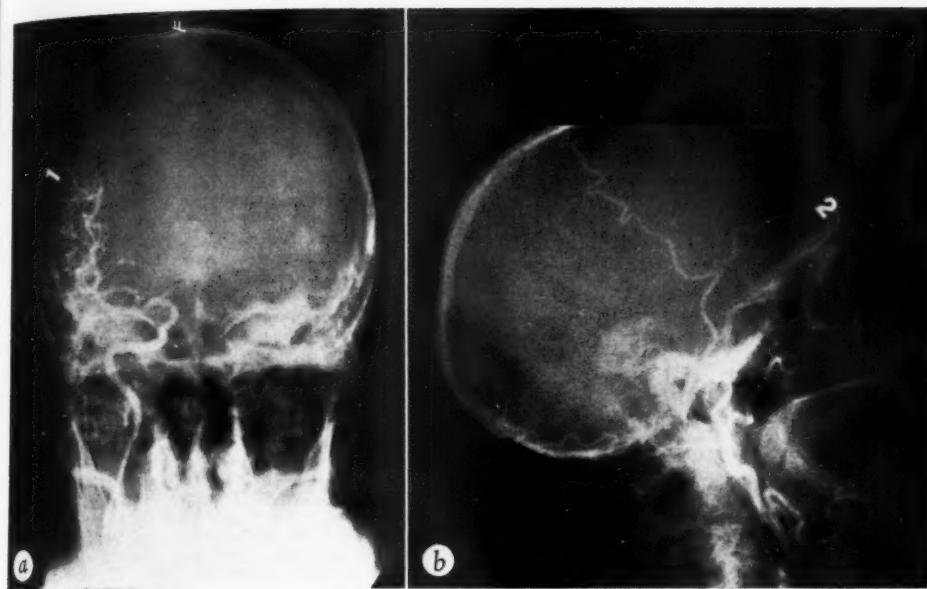


Fig. 4. a. Right carotid angiogram. Anteroposterior view reveals some filling of the intracranial vessels. b. Lateral view made three minutes later. The internal carotid artery is occluded at its origin. Note that needle tip is at point of occlusion.

ance of a neurologic deficit or worsening of one already present. The changes were persistent in 5 cases and temporary in 6. In all of these latter patients the neurologic status improved to the pre-angiographic level in one to three days.

All neurologic complications were associated with injection into the carotid artery. As might be anticipated, the stenosis was moderate to severe in 3 of these cases, and minimal in only 1. In 6 patients complications occurred unexpectedly when medium was injected into a completely occluded internal carotid artery. These latter occurrences would seem to exclude embolus and the toxic effects of high concentrations of contrast medium as the cause of the difficulties. It is possible that trauma to the wall of the carotid artery in the neck, incident to puncture, could cause reflex narrowing of the intracranial vessels and result in diminution of cerebral blood flow in an already compromised vascular bed. This in turn could produce cerebral infarction in certain cases.

Dramatic evidence that excess trauma

to the arterial wall should be avoided was presented in 2 of our early cases in which the internal carotid artery became occluded during the period between the first and second injections. Figure 4 demonstrates the close proximity of the needle tip to the origin of the internal carotid artery. Immediate surgical exploration in 1 case revealed severe atheromatous disease in the region. Removal of a fresh thrombus from the vessel did not benefit the patient.

The final neurologic complication (primarily aphasia) was observed in a patient with a parasagittal meningioma. Removal of the tumor led to marked relief of symptoms.

SURGICAL RESULTS

Thirty-six patients were deemed suitable candidates for surgical treatment after analysis of the history, neurologic status, type and location of the arterial lesions, and other factors. Table I gives the results that were obtained. It is evident that operation was most beneficial in the group with incipient stroke. Sixty per cent of these patients were relieved of their symp-

TABLE I: SURGICAL RESULTS IN 36 PATIENTS

Incipient Stroke Result	Patients	Completed Stroke Result	Patients
Flow unchanged	3	Flow unchanged	4
Flow restored	22	Flow restored	7
Relieved	15	Improved	1
Recurred	5	Unchanged	5
Deaths	2	Worse	1
TOTAL	25		11

toms. In the presence of a completed stroke, only occasional benefit can be expected.

SUMMARY

Ninety-six carefully selected patients with clinically diagnosed cerebrovascular disease were subjected to 154 angiographic examinations in an attempt to determine the causes of the symptoms. In most cases percutaneous injections into the carotid and subclavian arteries were utilized for the examination. All four of the major vessels supplying blood to the brain were visualized in 13 cases, three of the vessels in 27 cases, and one or two vessels in the remainder.

Abnormal findings were demonstrated in 80 per cent of the cases, including arterial occlusion in 34 and atherosclerotic stenosis in 38. Complications occurred in 13 cases and included 1 death, 1 pneumothorax, and 11 instances of cerebral damage producing neurologic deficit.

Surgical therapy seems to be of some value in patients with incipient strokes but is of questionable efficacy in those with completed strokes.

Mayo Clinic
Rochester, Minn.

REFERENCES

- WELLS, C. E.: The Cerebral Circulation: The Clinical Significance of Current Concepts. *Arch. Neurol.* **3**: 319-331, September 1960.
- HULTQUIST, G. T.: Quoted by Fisher (3).
- FISHER, M.: Occlusion of the Internal Carotid Artery. *Arch. Neurol. & Psychiat.* **65**: 346-377, March 1951.
- FISHER, M.: Occlusion of Carotid Arteries: Further Experiences. *Arch. Neurol. & Psychiat.* **72**: 187-204, August 1954.
- SAMUEL, K. C.: Atherosclerosis and Occlusion of the Internal Carotid Artery. *J. Path. & Bact.* **71**: 391-401, April 1956.
- ADAMS, R. D.: Mechanisms of Apoplexy as Determined by Clinical and Pathological Correlation. *J. Neuropath. & Exper. Neurol.* **13**: 1-13, January 1954.
- HUTCHINSON, E. C., AND YATES, P. O.: The Cervical Portion of the Vertebral Artery: A Clinicopathological Study. *Brain* **79**: 319-331, June 1956.
- HUTCHINSON, E. C., AND YATES, P. O.: Carotico-Vertebral Stenosis. *Lancet* **1**: 2-8, Jan. 5, 1957.
- ROB, C., AND WHEELER, E. B.: Thrombosis of Internal Carotid Artery Treated by Arterial Surgery. *Brit. M. J.* **2**: 264-266, Aug. 3, 1957.
- BAHNSON, H. T., SPENCER, F. C., AND QUATLEBAUM, J. K., JR.: Surgical Treatment of Occlusive Disease of the Carotid Artery. *Ann. Surg.* **149**: 711-720, May 1959.
- DE BAKEY, M. E., CRAWFORD, E. S., COOLEY, D. A., AND MORRIS, G. C., JR.: Surgical Considerations of Occlusive Disease of Innominate, Carotid, Subclavian, and Vertebral Arteries. *Ann. Surg.* **149**: 690-710, May 1959.
- DE BAKEY, M. E., CRAWFORD, E. S., AND FIELDS, W. S.: Surgical Treatment of Lesions Producing Arterial Insufficiency of the Internal Carotid, Common Carotid, Vertebral, Innominate and Subclavian Arteries. *Ann. Int. Med.* **51**: 436-448, September 1959.
- FIELDS, W. S., CRAWFORD, E. S., AND DE BAKEY, M. E.: Surgical Considerations in Cerebral Arterial Insufficiency. *Neurology* **8**: 801-808, November 1958.
- GURDJIAN, E. S., WEBSTER, J. E., HARDY, W. G., AND LINDNER, D. W.: Surgical Considerations in the Management of Cerebrovascular Disease. *Minnesota Med.* **41**: 327-331, May 1958.
- GURDJIAN, E. S., HARDY, W. G., AND LINDNER, D. W.: The Surgical Considerations of 258 Patients With Carotid Artery Occlusion. *Surg., Gynec. & Obst.* **110**: 327-338, March 1960.
- KEIRNS, M. M., AND WHITELEATHER, J. E.: The Angiographic Study of Carotid Insufficiency and Cerebral Ischemia. *Am. J. Roentgenol.* **81**: 929-944, June 1959.
- MURPHEY, F., AND MILLER, J. H.: Carotid Insufficiency—Diagnosis and Surgical Treatment: A Report of Twenty-One Cases. *J. Neurosurg.* **16**: 1-23, January 1959.
- JAVID, H.: Surgical Management of Cerebral Vascular Insufficiency. *Arch. Surg.* **80**: 883-889, June 1960.
- McDOWELL, F. H., SCHICK, R. W., FREDERICK, W., AND DUNBAR, H. S.: An Arteriographic Study of Cerebrovascular Disease. *Arch. Neurol.* **1**: 435-442, October 1959.
- SILVERSTEIN, A.: Occlusive Disease of the Carotid Arteries. *Circulation* **20**: 4-16, July 1959.
- KUHN, R. A.: The Revolution Produced by Cerebral Angiography in Management of the Patient With "Stroke." *J. M. Soc. New Jersey* **56**: 68-75, February 1959.
- CRAWFORD, E. S., DE BAKEY, M. E., FIELDS, W. S., COOLEY, D. A., AND MORRIS, G. C., JR.: Surgical Treatment of Atherosclerotic Occlusive Lesions in Patients With Cerebral Arterial Insufficiency. *Circulation* **20**: 168-180, August 1959.

SUMMARIO IN INTERLINGUA

Investigation Angiographic de Insufficiencia Cerebrovascular

Novanta-sex cautemente seligite patientes con clinicamente diagnosticate morbo cerebrovascular esseva subjicite a 154 examines angiographic con le objectivo de determinar le causa del symptomas. In le majoritate del casos, injectiones percutanee ad in le arterias carotic e subclavian esseva utilisate in le examine. Le complete gruppo del quattro major vasos alimentante le cerebro esseva visualisate in 13 casos, tres del quattro in 27 casos, e un o duo in le alteres.

Constatationes anormal esseva facite in 80 pro cento del casos. Occlusion arterial esseva demonstrate in 34 casos e stenosis atherosclerotic in 38. Complicationes occurreva in 13 casos, incluse 1 morte, 1 pneumothorace, e 11 occurrentias de damno cerebral con resultante deficit neurologic.

Il pare que therapia chirurgic es de valor in patientes con incipientia de attacco apoplectic, sed illo es de dubitose efficacia in patientes con apoplexia completate.



Antegrade Aortography and Arteriography

Further Experience With the Method
Its Place in Arterial Opacification Techniques¹

LIEUT.-COL. LONGSTREET C. HAMILTON, MC, USA, and CAPT. WILLIAM V. WELDON, MC, USA

ROENTGENOGRAPHIC visualization of the left circulation, primarily the aorta and its branches, following injection of opaque medium into the right circulation, has been described by Greenspan *et al.* (5), Steinberg *et al.* (11), Sutton *et al.* (12), and, in a previous paper, by the Walter Reed Hospital group (14).

The purpose of the present report is twofold: first to add to the recorded experience with the various methods of antegrade aortography; second, to attempt to assess the value of the procedure in various clinical situations. The venous and right atrial approaches were originally attempted to avoid the difficulties and complications of arterial invasion. We have asked ourselves three questions. Is antegrade aortography safer and easier than retrograde methods? What are the indications for this procedure? Under what circumstances would retrograde aortography or selective arteriography be preferable?

METHOD AND MATERIALS

Experience with translumbar and retrograde aortography led to our first efforts with aortography *via* the right circulation in November 1959. A disappointing number of attempts with intravenous injection, both unilateral and bilateral, had ended with large portions of the bolus trapped in axillary and subclavian veins. We turned, therefore, to catheterization of the right atrium in the manner usual for selective angiography as the means of injection, on the premise that the opaque bolus delivered there would be least subject to dilution. As of August 1960,

TABLE I: DECHOLIN CIRCULATION TIME (RIGHT ATRIUM-TO-TONGUE)

Time in Seconds	No. of Patients
6	2
7	1
8	17
9	21
10	19.89%
11	17
12	15
13	4
14	3
18	1
TOTAL	100

125 aortographic examinations for various problems had been attempted by this method. We have had a high rate of diagnostic success, with no complications of any consequence.

Our procedure is similar to those previously described. The median basilic vein is entered with an N.I.H. catheter which is passed into the right atrium under fluoroscopy. No anesthesia, other than local for the venous cut-down, is required. Circulation time from atrium to tongue is determined with Decholin and from atrium to popliteal artery with material labeled with radioactive iodine. For the latter purpose I^{131} -labeled Diodrast and, later, Hippotope were used, with a scintillation counter and Esterline-Angus recorder. The circulation times are employed as a basis for timing both serial films of the area of primary interest (abdominal aorta and branches, or aortic arch and branches) and a single film, made with portable machine, of the other aspect of the aorta or of the femoral and popliteal arteries. Filming in the area of primary interest, with the Schönander apparatus, is begun

¹ From the Radiology Service, Walter Reed General Hospital, Walter Reed Army Medical Center, Washington 12, D. C. Presented in abridged form under the title "Forward Aortography" at the Forty-sixth Annual Meeting of the Radiological Society of North America, Cincinnati, Ohio, Dec. 4-9, 1960.

This material has been reviewed by the Office of the Surgeon General, Department of the Army, and there is no objection to its presentation and/or publication. This review does not imply any endorsement of the opinions advanced or any recommendation of such products as may be named.

about five seconds prior to the time indicated by the Decholin test and continued at the rate of one film every 1.33 seconds for 20 seconds. A plain abdominal film is made ten minutes later, unless the patient has already had a pyelographic examination.

Alternate loading of the Schönander magazines for frontal and lateral projections eliminates the problem of scatter-toggling in the opposite plane. With our equipment the lateral view of the abdomen has been successful only in smaller adults and children. We have occasionally limited lateral exposures to three or four films at a time calculated to show maximum density of the vessels. Good quality biplane visualization is in our opinion necessary for the highest accuracy, and we have not yet been satisfied with lateral projections for larger patients. Difficulty in this respect has also been recorded by Ödman (10), with apparatus capable of 400 ma at 150 kv, which considerably exceeds our permissible factors.

Continuous electrocardiographic monitoring is done on every patient. By use of the Sanborn 4-channel Polyviso recorder, a record was made of the beginning and duration of injection, the time and duration of each frontal and lateral roentgen exposure, and one lead of the electrocardiogram. This record, except for the electrocardiogram, is probably not necessary to the success of the procedure, but it allowed us to assess injection times with catheters of various sizes and to correlate time of appearance of the opaque medium at various sites with the previously determined circulation time. It also afforded an indicator of the effect on cardiac action during and after high-pressure injection into the atrium.

The opaque medium employed was 90 per cent Hypaque in doses of 1.2 c.c./kg. of body weight. The Gidlund automatic pressure injector was used, with the pressure invariably at 10 kg./cm. Because of our previous experience with both rupture of the catheter and failure of the Luer-Lok mechanism of the Gidlund syringe, special

TABLE II: INDICATIONS FOR PERFORMANCE OF ANTEGRADE AORTOGRAPHY

	CASES
Evaluation of renal vasculature for hypertension.....	38
Occlusive disease of abdominal aorta and its branches.....	34
Aortic arch syndromes.....	32
Atherosclerosis, thrombosis, arteritis.....	27
Coarctation, anomalies, vascular ring.....	5
Acute aortic arch lesions.....	2
Marfan's syndrome with recent dissection.....	1
Traumatic aortic aneurysm.....	1
Evaluation of masses.....	9
Aneurysm and other mediastinal and abdominal masses.....	7
Renal mass lesions.....	2
Postoperative graft assessment.....	10
TOTAL CASES.....	125

measures were taken to avoid these accidents. A stainless steel collar fitting over the tubing of the catheter and abutting on the metal hub was threaded to screw tightly onto the outer collar of the Luer-Lok connection. In addition, the catheter was taped to the steel collar. With these precautions we have had successful injections even when the catheter base separated from its metal hub during the high-pressure injection.

The films and work sheets (record of technical factors) together with clinical charts of 125 patients studied by aortography were reviewed. The cases were tabulated according to the indication for the procedure (Table II). All of the films

TABLE III: ANTEGRADE AORTOGRAPHY RESULTS: REASONS FOR UNSATISFACTORY EXAMINATION

	Cases
Insufficient opacification.....	5
Catheter too small (slow injection).....	2
Cause not recorded.....	1
Supraventricular tachycardia with change in circulation time and noncompact bolus.....	1
Reflux into hepatic veins and IVC.....	1
Mechanical failure or catheter rupture.....	2

of each study were re-examined and a purposefully retrospective opinion was recorded as to whether aortography served an essential role in the conduct of the case, which areas needed improved visualization, and reasons for unsatisfactory results (Table III). With the beginning of injection taken as zero, opacification times were recorded, including the time both of first visualization and optimal opacification of the aortic arch and the common carotids, subclavians, upper abdominal

TABLE IV: OPACIFICATION TIMES FROM RIGHT ATRIUM; VARIANCE FROM DECHOLIN CIRCULATION TIME

	Range of Actual Opacification Time (Sec. from 0*)		Variance from Decholin Circulation Time (Sec.)	None	±2 sec.	Over 2 Sec.
Aortic arch and common carotid arteries	6-15	-5 to +5	25%	88%	12%	
Subclavian arteries	8-16	-5 to +5	23%	72%	28%	
Abdominal aorta and renal arteries	8-18	-5 to +7	18%	65%	35%	
Nephrogram†	7-17	-3 to +5	22%	79%	31%	
Bifurcation aorta	8-22	-4 to +10	18%	52%	48%	

* Zero seconds is the beginning of injection.

† Time given here is earliest appearance. In other four areas, time of optimal opacification (one to three seconds after first appearance) is given.

TABLE V: AUXILIARY SINGLE FILMS

	No. of Attempts	Success	Failure
Aortic arch and neck*	40	28(70%)	12
Abdominal aorta†	18	12(66%)	6
Femoral and popliteal‡	29	16(55%)	13

* Taken at Decholin circulation time.

† Taken one or two seconds after Decholin circulation time.

‡ Taken at I^{131} circulation time.

TABLE VI: MAXIMUM DOSES 90 PER CENT HYPAQUE* (Double Injections at the Same Examination)

Case No.	Reason for Double Injection	Body Wt. (lb.)	Dose (c.c.)
13	Timing failure due to supraventricular tachycardia	114	124
25	Mechanical failure	169	184
26	Repositioning for additional information	155	164
47	Repositioning for additional information	150	160
107	Repositioning for additional information	125	136
109	Repositioning for additional information	163	178
121	Repositioning for additional information	140	152

* Standard dose 1.2 c.c./kg. body weight. Maximum dose per single injection 100 c.c.

It is worth noting that, of these cases, only 1 is represented among the complications.

aorta and renal arteries, bifurcation of the aorta, and some veins, as well as the nephrogram, the hepatogram, and the splenogram. Some of the figures were correlated with the Decholin circulation time (see Table IV and under the sub-head "Results"). The efficiency in obtaining useful or diagnostic single films in the area of secondary interest was assessed (Table V). Data were collected on amounts of opaque medium injected, the catheter size, and the rate of injection and were correlated with the quality of

opacification (Tables VI and VII). There were no major complications; the minor complications are compiled in Table VIII. Note was made of symmetry or asymmetry in the size of the carotid, subclavian, and vertebral arteries, and of the number of accessory renal arteries seen.

RESULTS

Successful opacification of the aorta and its branches was obtained in 118 cases (94.4 per cent). Unilateral renal disease or anomaly was discovered in 10 of the 38 patients investigated because of hypertension. Included were arteriovenous malformation, possible infarction, aneurysm of the renal artery, and partial obstruction of the renal artery by arteriosclerotic plaque and stricture. In the remaining 28 cases the findings were normal. In the other categories the pre-examination diagnosis was confirmed or refined, and pertinent anatomic data were obtained, except for 9 cases evaluated for carotid or basilar insufficiency. In these the examination was negative.

Fifteen cases deserve special comment. In all of these, after the clinical data were weighed and the film findings were discussed, a diagnosis was reached, and a repeat examination was not considered necessary. The x-ray images were subject to discussion, however, in five groups.

The first group consisted of problems of carotid or basilar insufficiency, and the examination was aimed mainly at the arch of the aorta, the common carotids, and the vertebral arteries, but the bifurcation of the common carotid is also a surgically important

TABLE VII: INJECTION RATE*

(N.I.H.) Catheter Size	c.c./sec.		Bolus (Opacification) Quality			
	Range	Average	Unsatisfactory	Fair	Good	Excellent
No. 10	58-106	73	..	..	8	3
No. 9	37-55	44	..	4	5	..
No. 8	29-46	33	..	4	11	..
No. 7	11 & 21	15	2	..	..	..

* With Gidlund injector at 10 kg./cm.² Catheter size, volume of dose, and time of injection were recorded in 37 cases.

tant area. Because of the variable plane of this bifurcation, visualization was not unequivocally diagnostic in 4 of these cases. This was due not only to positioning difficulties involved in the attempt to see both bifurcations at once, but also to the quality of the bolus of opaque material. We believe that intra-atrial injection provides the optimal bolus of any antegrade technic, but none of the methods can equal the detail afforded by the almost complete displacement of blood by opaque medium in the vessel lumen, as in selective arteriography. The antegrade aortogram, however, has the advantages that a survey of both carotids and vertebrals can be obtained, and that puncture of arteriosclerotic vessels can be avoided. We have recently visualized the vertebrals, basilar artery, and both carotids from arch to siphon with a single injection. This has led us to hope that further experience with positioning the head and neck and with technical factors will give results more comparable to selective arteriography in this area.

In 3 cases in which defects in the renal vasculature as a cause of hypertension were sought, no defects were seen, and there was no delay in the filling of the renal arteries, or in the appearance of the nephrogram. In these 3 instances, however, the roots of the renal arteries were so situated that their shadows could not be separated from that of the aorta. This is not peculiar to antegrade aortography, being a problem in retrograde studies also. Probably small multiple local injections with various projections other than the anteroposterior and lateral would solve the problem.

Two cases of renal mass are included in

TABLE VIII: COMPLICATIONS

Cardiac arrhythmias* (supraventricular tachycardia of short duration following injection).....	2
Allergic reactions.....	4
Morbilliform skin rash.....	1
Urticaria.....	3
Extravasation of opaque medium†.....	6
Thrombophlebitis‡.....	2
TOTAL.....	14

* Most of the cases showed one or two premature beats on the electrocardiogram during the one-to-three-second period of injection only.

† Noted as small area of opacification persisting after intraluminal medium had disappeared. None of the patients had any symptoms or signs. Chest films revealed prompt absorption with no evidence of bleeding or hematoma formation.

‡ Statement available for 85 cases only. Records available on the other 40 patients make no mention of this complication. Both cases responded to treatment in two or three days.

the 15 cases. The differentiation of cyst from neoplasm is not absolute, even with the best of selective arterial opacification. Edsman's (4) large experience with renal angiography indicated that there is considerable value in a sharply defined bolus, with which arterial and capillary phases of the nephrogram can be evaluated. The bolus with antegrade aortography is necessarily unsharp, so that these 2 cases are considered with the problem groups, even though the roentgen diagnosis of cyst was surgically proved in one and clinically proved in the other by absence of change over a years follow-up.

In 2 cases films of satisfactory quality failed to disclose a reason for pulse deficit in the right subclavian (diminished) blood pressure; pulse present but slightly weaker than on opposite side. In one of these, a case of Marfan's syndrome with recent symptoms of dissection, dilatation of the aorta was visualized and the extent of dissection correctly assessed. In the other, arteriosclerotic plaques were diagnosed in the vertebral root. Failure to demon-

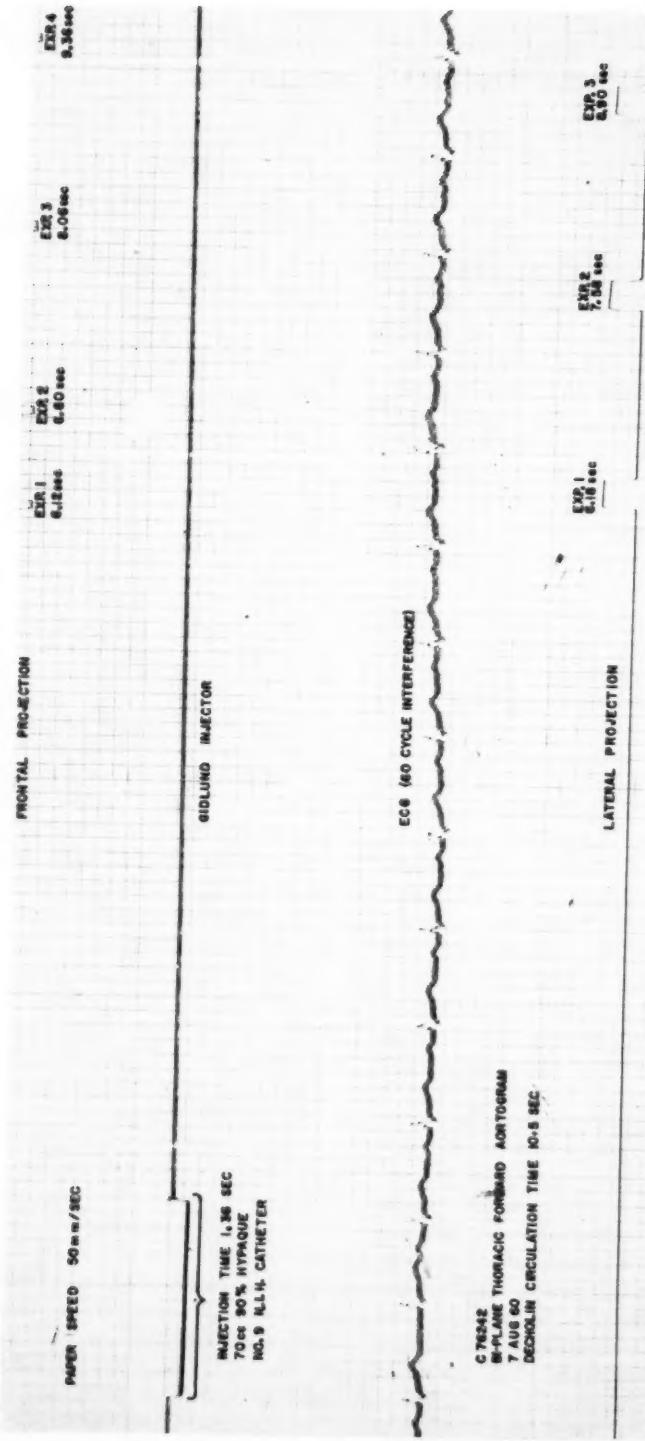


Fig. 1. Four-channel Sanborn Polyviso record of a biplane thoracic aortographic study. Beginning of the injection is taken as zero seconds.

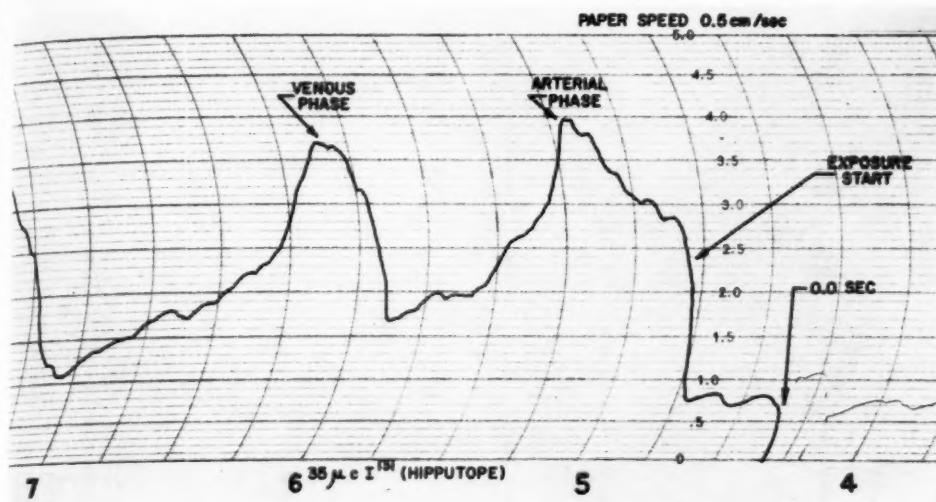


Fig. 2. Esterline-Angus recording made over the popliteal area.

strate the partial subclavian obstruction may be due to positioning. The antero-posterior projection in this area is, overall, the most rewarding, and we did not believe that second injections with oblique positioning were justified in these problems. Even though biplane films are made with the initial injection, the lateral projection shows only the neck and aortic arch areas well. The inclusion of these 2 cases in the equivocal category is perhaps unfair to the method; retrograde aortography might show the same deficiency, but a sharp bolus of opaque medium improves accuracy.

Finally, 4 cases are included mainly as unproved with positive findings. In 2 a unilateral delay in the appearance of the nephrogram was shown, and in 2, a difference in density in the nephograms. Definite partial occlusion (filling defect) of the renal artery could not be detected in any of these cases. Two of the patients have not yet been subjected to surgery but probably will be; the other 2 had generalized arteriosclerotic disease. Hypertension was not the most pressing problem in these last 2, and they will not be operated on for renal-artery investigation.

On the other side of the ledger, in 9 cases findings were recorded on the aorto-

gram which might be classified as unexpected dividends. Unilateral partial occlusion of a renal artery was seen in a forty-year-old male investigated for arteriosclerotic claudication of the lower extremities. Small aneurysms of the abdominal aorta were found in 2 cases, and an aneurysm of the hypogastric artery in 1. The accessory films in 5 patients showed arteriosclerotic disease to be more extensive than clinically suspected.

The data in Tables IV and V indicate that with serial filming the Decholin circulation time could be dispensed with, since the entire range of opacification times is covered by the procedure. They also indicate, however, that its determination is worthwhile in so far as the head and neck are concerned, since single films taken at a time based on the test will succeed in about three-fourths of the patients. Further down the aorta and its branches, the success rate diminishes. The I^{131} method seems more accurate in our later experience, and it may be that the high failure rate with the thigh run-off films should be charged to inexperience of the operators rather than to inherent defects in the method. Another factor in this failure rate may be that we have injected the Hipputope or Diodrast by hand, in a



Fig. 3. Antegrade aortogram of a 27-year-old woman with "pulseless disease." The clinical course of arteritis was confirmed by arterial biopsy. Serial films showed complete occlusion of both common carotid arteries, with some collateral formation, but the bulk of the blood to the brain is *via* the vertebral arteries. A previous attempt at retrograde aortography failed to give clinically useful information.

small bolus, rather than with mechanical pressure and a bolus equal to the final opaque injection. Single films, when timed properly to show adequate vascular filling with opaque medium, were frequently informative and occasionally surprising. They were considered as efforts to derive the maximum information from the injection without extra risk or discomfort to the patient. Serial films show sequential filling of partially blocked vessels, differences in nephrogram timing and density, collateral circulation, and the venous phase of opacification. This valuable and necessary information cannot be derived from a single film, no matter how accurate the circulation time. The multiple films in a number of cases helped in interpreting difficult anatomy. Reliance on a single film would have resulted in failure in 25 to 50 per cent of this series (Table IV).

Table VII indicates the effect of injection rate on results. The variations in cubic centimeter injected per second with the same size catheter and pressure are possibly explained by differences in the

smoothness of the inner wall of the catheter, the relationship of the catheter tip to the wall of the atrium, and variations in actual size of the catheter lumen and end-holes. In most of the cases a record was included of the time and the amount of injection, though not of catheter size. These were not tabulated. Noteworthy instances include one record indicating the injection of 83 c.c. in 0.4 second (a rate of 200 c.c. per second) and another showing 40 c.c. in 3.9 seconds, with an adequate examination in spite of the rate of 10 c.c. per second. In general, the figures suggest that 30 c.c. per second is the minimum rate for an adequate bolus, and that the best films are obtained when practically the entire atrium is filled within one to two seconds. Every effort should be made to use a No. 8 or larger catheter.

The tabulation of complications needs little comment. We are prepared at all times to cope with serious cardiac arrhythmia or contrast reaction but fortunately we have not been confronted with such incidents. In regard to extravasation, 1 of the 6 cases was that mentioned above with an injection rate of 200 c.c. per second. In another, with two catheters in the atrium—one for pressure monitoring—the mean atrial pressure rose from 7 to 15 mm. Hg during injection through a No. 9 catheter of 100 c.c. 90 per cent Hypaque at 10 kg./cm.² pressure. In the other 4, injection rates were 32, 37, 46, and 67 c.c. per second, respectively.

A few other aspects deserve brief comment. A splenogram (diffuse opacification of the spleen with definite outlines) was obtained in 17 of 31 cases in which the spleen was on the film. It appeared from seven to nineteen seconds after injection, about paralleling the maximum opacity of the abdominal aorta and splenic artery. The density became maximum two or three seconds later and persisted essentially unchanged throughout the examination (twenty-three to twenty-eight seconds after injection). An hepatogram appeared in 11 of these same cases, at

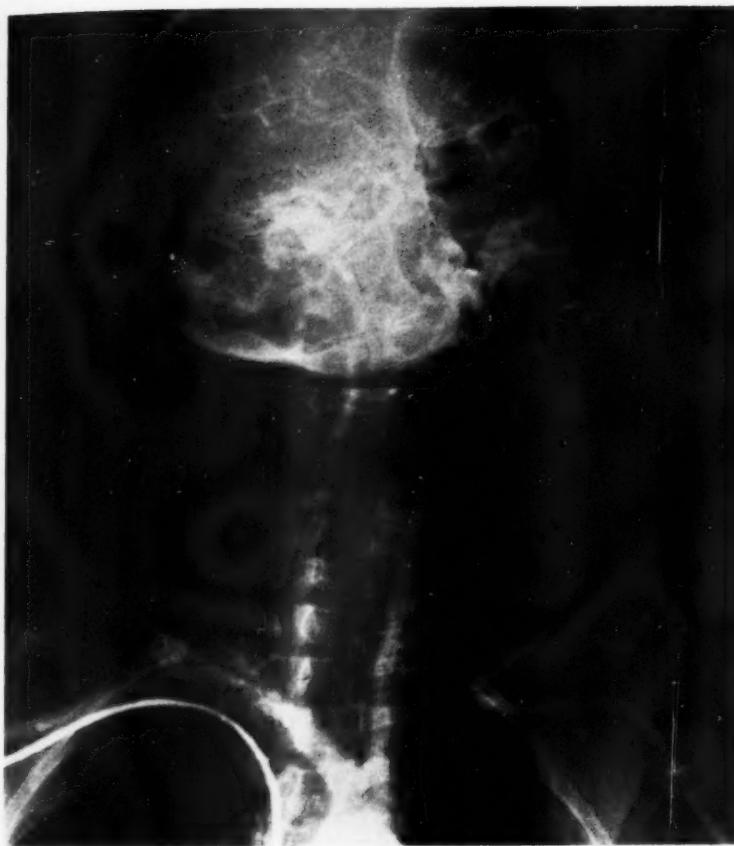


Fig. 4. Woman with signs and symptoms of basilar and carotid insufficiency. Patients in whom extensive multiple artery disease is suspected are particularly suitable subjects for antegrade aortography.* In this projection an attempt was made to show all branches of the aortic arch up to their intracerebral aspects, and the basilar artery and portions of the intracerebral carotids are included. Atherosclerotic disease is demonstrated in the original study in the right common and internal carotids and left vertebral artery. Technical factors can be improved upon.

about the time of maximum opacity of the spleen, when the portal vein began to return opacified blood to the liver, becoming optimal about three seconds later, and persisting throughout the examination.

Venous structures were visualized consistently in the neck and erratically in the abdomen. The jugular veins were seen three to six seconds after optimum opacification of the carotids. Only a single jugular was seen in 3 cases (no visualization of the right in 2, nor of the left in 1). In 1 of these patients the nonvisualized vein was found to be present and patent at surgery the following day. Among 48

cases in which the veins of the abdomen were assessed, both renal veins filled in 12, and the left only in 11; these veins appeared from one to seven seconds after maximum opacification of the aorta and renal arteries, the average interval being five seconds. The splenic vein was seen in 9 of 31 cases in which the proper area was shown, appearing about four seconds after optimal opacification of the aorta. The portal vein could be seen in 5 of these at about the same time. The ovarian vein filled in a retrograde fashion in 2 cases. The inferior vena cava was not seen. In general, the venous phases appeared

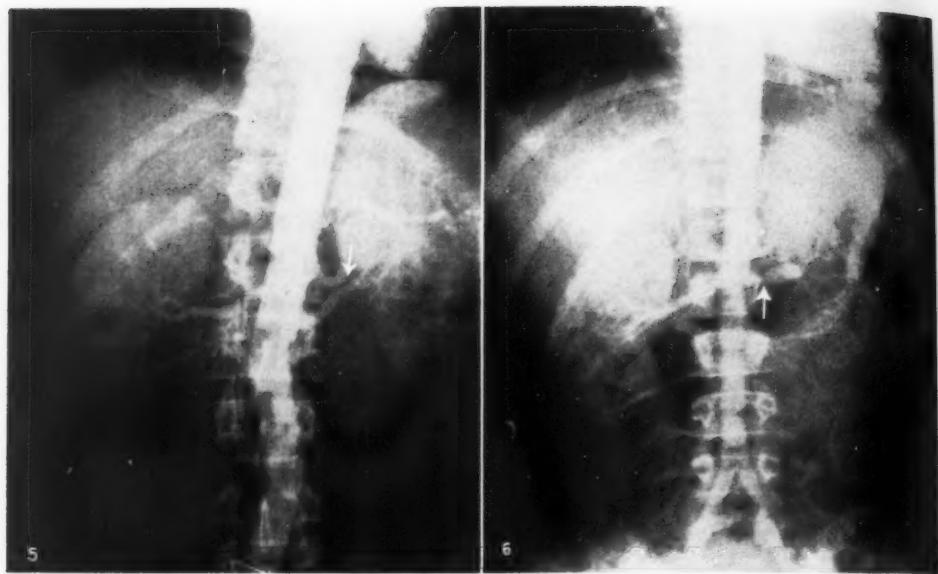


Fig. 5. Twenty-seven-year-old man with hypertension. The tiny defect in the left renal artery proved to be due to intimal thickening. Patch graft did not change the pressure gradient and nephrectomy was performed. Following surgery, the blood pressure was normal. The case shows that antegrade aortography can demonstrate tiny defects in properly placed vessels.

Fig. 6. Twelve-year-old boy with hypertension. Note the delayed nephrogram, due to constriction with post-stenotic dilatation in the left renal artery. Blood pressure after surgery was normal.

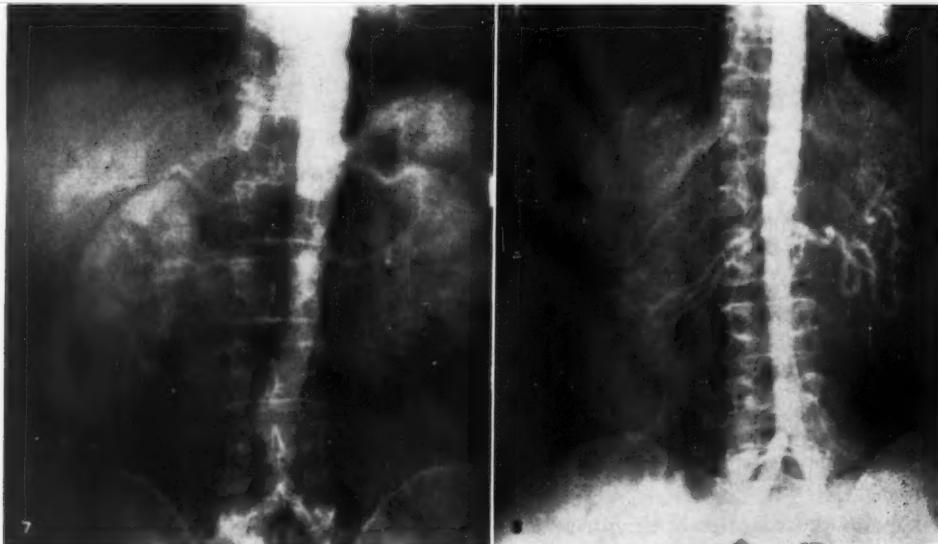


Fig. 7. Patient with intermittent claudication in the lower extremities and abdominal pain. The blood pressure was normal. Film shows atherosclerosis and aneurysmal formation in the aorta. The nonvisualization of the right renal artery persisted in spite of no delay in the appearance of the nephrogram.

Fig. 8. Examination was performed for mass in lower pole of the left kidney. This and later films with well developed nephrogram indicate that the mass is a cyst. The patient was thin and the technic was optimal. Film illustrates the problems of adequate visualization of the roots of the renal arteries and of arterial detail in the nephrogram. (See text.)

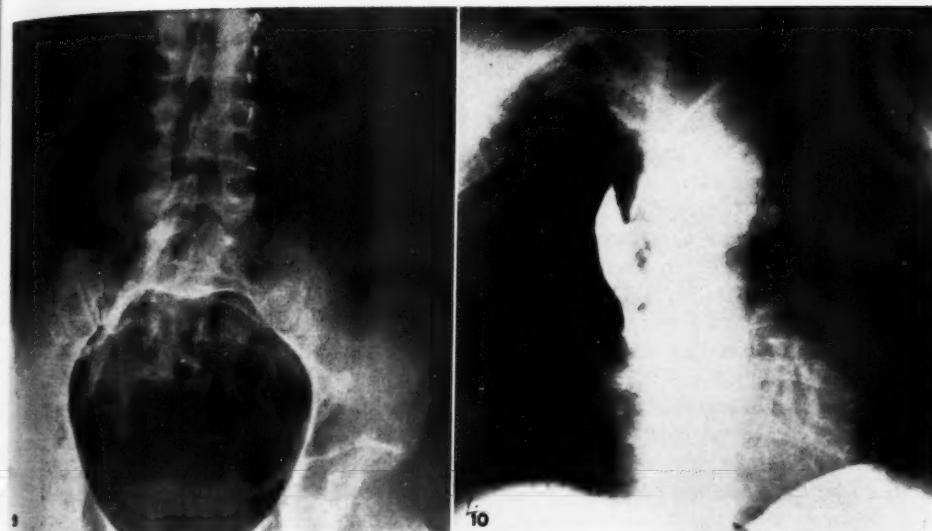


Fig. 9. Leriche syndrome. Complete occlusion of the left common iliac artery, with visualization of a long thrombus in the right common iliac artery. The thrombus was surgically removed.

Fig. 10. Extravasation around the superior vena cava in a patient with no symptoms. Follow-up chest films over the next forty-eight hours revealed no abnormality.

erratically and did not add pertinent information in this series except in the arteriovenous malformations. They represent, however, a potential field of usefulness in the search for evidence of mass lesions in the abdomen, spleen, or liver.

The common carotid arteries were usually equal in size unless abnormal. The relative size of the vertebral arteries was recorded in 44 cases: in 11 they were equal in size; in 9, the right was larger than the left; in 19 the left was the larger. In at least 2 of the 19, the difference was probably due to disease rather than to mere asymmetry. In 3 cases no right vertebral artery and in 2 no left vertebral artery was visualized, the vessel being either absent or completely occluded at its origin. Vertebral arteries arising from the arch did not occur in this series.

The splenic artery was usually well visualized and tortuous. The superior mesenteric filled regularly but was difficult to define clearly because of its frequent position directly over the aorta.

The renal artery was duplicated on one side in 7 patients (double on the left in 2; on the right in 5) and bilaterally in 4

instances. These 11 cases were collected from 66 records and represent an incidence of 16.6 per cent of patients with accessory vessels. In Edsman's series of nearly a thousand cases, one-third showed accessory renal arteries.

DISCUSSION

We believe antegrade aortography is safer and easier than arterial injection. Ödman (10) reported on 61 percutaneous arterial catheterizations. Difficulties mentioned were thrombosis and embolism (1 case each), failure to pass the catheter to the desired location due to tortuosity of pelvic vessels and aorta, fever in 10 cases, and hematoma at the puncture site in 22. Dotter (3) indicated that a considerable risk to the catheterized artery must be accepted, as well as the risk of cerebral embolism when the catheter is proximal to the carotids. Our experience with retrograde aortography includes arterial thrombosis and a case of transient hemiplegia. The procedure is time-consuming, especially in closure and clearing the vessel of clots. On the other hand, the percutaneous technic is probably less time-con-

suming than venous cut-down. It would appear from these reports that direct injection of diatrizoate into the aorta near renal and other branches is safe. Reports (1, 2, 9) of complications of trans-lumbar aortography suggest that renal damage, paralysis, and visceral necrosis may be due to toxicity of the medium (iodopyracet, sodium acetrizoate) and are not necessarily inherent in the method. Reports by Killen *et al.* (7), Thomson *et al.* (13), and Hoppe and Archer (6) strengthen the conviction that diatrizoate is far less toxic. Even if no complications result from direct injection of diatrizoate into the arteries, however, catheterization from the venous side of the circulation will still have to be rated as a procedure safer for the patient than any of the arterial methods. Another factor to be considered is the added hazard of arterial invasion in the patient with arteriosclerotic plaques susceptible to dislodgment and embolization, and with tortuous arteries with weakened walls susceptible to perforation.

Antegrade aortography is at present indicated for investigation of those arterial injuries, diseases, and malformations affecting the aorta and its major branches. We hope that, with improvement of equipment and positioning, this field can be extended to smaller vessels as Steinberg *et al.* (11) have predicted. Some success has been realized with carotid bifurcations, the basilar artery, the popliteal bifurcation and, in a case examined after the 125 here tabulated, the brachial artery in an arterio-venous malformation. Clinically localized disease in the neck is at present better studied with selective arteriography. Evaluation of the renal arteries in young patients with hypertension but no evidence of generalized atherosclerosis will possibly be improved by selective intra-arterial injection, and experience should be accumulated with the percutaneous method in this group. It is possible, however, that the risk of arterial thrombosis and embolization will be greater than that of failure to visualize minute abnormalities. Lowman (8) states that the diameter of an

artery must be reduced to 70 per cent of normal before significant manifestations of blood-flow impairment are noted. The quality of opacification with antegrade aortography is certainly capable of revealing defects of this magnitude. There is also the consideration that a good bolus of opaque medium is not invariably obtained even with retrograde methods. It is possible that our filming rate is too leisurely and that a higher rate during filling of the renal arteries and development of the nephrographic phase would improve results.

The obvious areas in which retrograde and selective methods are preferable are the study of coronary and intracranial vessels and the aortic valves. Patients with disease localized to one vessel, especially where fine detail may be necessary and the more peripheral and smaller arteries are involved, are candidates for selective intra-arterial opacification.

CONCLUSIONS

Antegrade aortography is a safe and easy procedure with a wide range of indications, especially in the investigation of occlusive arteriosclerotic disease, where vessel tortuosity and plaques increase the hazard of arterial invasion. It is a suitable survey procedure for problems of vascular insufficiency in the head and neck but, in respect to detail afforded, cannot equal selective arteriography and is not to be preferred in clinically localized problems. In the investigation of hypertension, antegrade aortography is probably safer but perhaps less reliable than retrograde methods. A reconsideration of retrograde approaches in young hypertensive patients without arteriosclerosis is indicated, since new and safer opaque media are available.

Considerable specialized equipment and a trained team are necessary to obtain maximum information from the procedure. As now performed at Walter Reed General Hospital, the procedure has a success rate in the aorta and large arteries of 95 per cent, and in smaller vessels of 50 to 85 per cent. Efforts to extend its range of

useful
visual
during
better
off"

U. S.
A. P.

1. LINTON
lumber
1113-
2. AND
Surg.
3. Arter
Meth
83: 5
4. renal
Nor
Lesie
155-
5. LOK
Yor

Ao
mi
su
co
sta
de
pe

br
pr
la
pa
si
In
fo
le
e
in
in
co

usefulness are justified. Good biplane visualization, a higher rate of serial filming during the phase of arterial filling, and better visualization of small vessel "run-off" areas are obvious avenues for these efforts.

U. S. Army Tripler General Hospital
A. P. O. 438, San Francisco, Calif.

REFERENCES

1. BARNES, B. A., SHAW, R. S., LEAF, A., AND LINTON, R. R.: Oliguria Following Diagnostic Translumbar Aortography. *New England J. Med.* **252**: 1113-1116, June 30, 1955.
2. CRAWFORD, E. S., BEALL, A. C., MOYER, J. H., AND DE BAKER, M. E.: Complications of Aortography. *Surg., Gynec. & Obst.* **104**: 129-141, February 1957.
3. DOTTER, C. T.: Left Ventricular and Systemic Arterial Catheterization: A Simple Percutaneous Method Using a Spring Guide. *Am. J. Roentgenol.* **83**: 969-984, June 1960.
4. EDSMAN, G.: Angiography and Suprarenal Angiography. A Roentgenologic Study of the Normal Kidney, Expansive Renal and Suprarenal Lesions and Renal Aneurysms. *Acta radiol.* Suppl. 155, 1957.
5. GREENSPAN, R. H., BERNSTEIN, E. F., AND LOKEN, M. K.: Intravenous Aortography. *Ann. New York Acad. Sc.* **78**: 924-942, July 1959.
6. HOPPE, J. O., AND ARCHER, S.: X-Ray Contrast Media for Cardiovascular Angiography. *Angiology* **11**: 244-254, June 1960.
7. KILLEN, D. A., LANCE, E. M., AND OWENS, G.: Relative Suitability of Urokon 70 Per Cent and Hypaque 90 Per Cent for Use as Aortographic Contrast Media. *Surgery* **45**: 436-444, March 1959.
8. LOWMAN, R. M.: Peripheral Arteriography: A Survey of the Newer Techniques and Problems. *Angiology* **11**: 218-226, June 1960.
9. McAFFEE, J. G., AND WILLSON, J. K. V.: A Review of the Complications of Translumbar Aortography. *Am. J. Roentgenol.* **75**: 956-970, May 1956.
10. ÖDMAN, P.: Percutaneous Selective Angiography of the Celiac Artery. *Acta radiol.* Suppl. 159, 1958.
11. STEINBERG, I., FINBY, N., AND EVANS, J. A.: A Safe and Practical Intravenous Method for Abdominal Aortography, Peripheral Arteriography, and Cerebral Angiography. *Am. J. Roentgenol.* **82**: 758-772, November 1959.
12. SUTTON, G. C., GRAHAM, J. B., AND BURKHEAD, H. C.: Innominate, Carotid, Renal and Iliac-Femoral Arteriography Employing Intravenous or Right Heart Size for Media Injection. *Quart. Bull. Northwestern Univ. M. School* **33**: 275-276, Fall 1959.
13. THOMSON, H. S., MARGOLIS, G., GRIMSON, K. S., AND TAYLOR, H. M.: Effects of Intra-Arterial Injection of Iodine Contrast Media on the Kidney of the Dog. *Arch. Surg.* **74**: 39-49, January 1957.
14. ZERBI-ORTIZ, A., AND WELDON, W. V.: Aortography by Catheterization of the Right Atrium. A Safe and Reliable Method. *New England J. Med.* **264**: 19-23, Jan. 5, 1961.

SUMMARIO IN INTERLINGUA

Aortographia Anterograde: Experientias Additional in le Uso del Methodo; Su Placia Inter le Technicas de Opacification Arterial

In un studio de 125 anterograde examenes aortographic, un alte procento de successo diagnostic esseva effectuate sin complicaciones de importantia. Le substantia de contrasto usate esseva Hypaque de 90 pro cento in doses de 1,2 cm³ per kg de peso corporee.

Successo de opacification del aorta e su brancas esseva obtenite in 118 casos (94,4 pro cento). Morbo o anomalia renal unilateral esseva discoperite in 10 inter 38 patientes investigate a causa de hypertension. In 24 le constataciones esseva normal. In le altere studios, le diagnose previamente formulate esseva confirmate o raffinate per le examine, e pertinente datos anatomic esseva obtenite in omne le casos excepte 9 in que le evalutation esseva concernite con insufficientia carotic o basilar e in que le constataciones esseva normal.

Le autores conclude, como resultado de lor observationes que aortographia anterograde es indicate currentemente in le in-

vestigation de injurias, morbos, e malformaciones arterial que affice le aorta e su major brancas, specialmente in occlusive morbo arteriosclerotic ubi tortuositate del vasos e placas augmenta le riscos del injection arterial. Le methodo es appropriate pro le investigation de problemas de insufficientia vascular in capite e cervice, sed illo non es equivalente a arteriographia selective con respecto al detallo providite, e illo non pote esser regardate como preferibile in casos in que le problema es clinicamente localisate. In le investigation de hypertension, aortographia anterograde es probabilemente plus salve, sed forsitan illo es minus fidel que le methodos retrograde.

In le forma in que le procedimento es executate currentemente al Hospital General Walter Reed, su quota de successos in le aorta e le grande arterias es 95 pro cento. In le vasos plus micre illo es inter 50 e 85 pro cento.

New Technic for Accurately Projecting the Dorsum Sellae into the Foramen Magnum¹

LEWIS E. ETTER, M.D., F.A.C.R.

FOR MANY YEARS the routine antero-posterior oblique Chamberlain-Towne projection of the skull has been used as originally recommended by Towne for studies of the petrous pyramid, especially for evidence of erosion by acoustic nerve tumors (1). In his paper published in December 1926, Towne, who was a neurologist, said: "Dr. W. E. Chamberlain of the Department of Roentgenology of Stanford University Hospital has recently succeeded in showing the destruction of the petrous bone in a verified case of acoustic nerve tumor. Instead of making lateral projections of the skull, in which the internal and external auditory meati of the two sides are identified with difficulty, he used a posterior projection in which the petrous bones are shown in profile. The two bones can thus be compared on one set of stereoscopic films. With the patient on his back, the head is flexed at the top of the neck, so that the chin is drawn backward. The center of the film is placed under the foramen magnum, and the central ray is directed at the center of the film through the midline of the frontal region, at a point about 3 inches above the level of the eyebrows." Figure 1 shows the conventional projection at 35° as used by most radiologists and x-ray technicians. The central ray is directed at the intersection of a perpendicular line which extends through the external canthus of the eye and the external auditory meatus.

For a long time radiologists have recognized that this view paid several dividends, notably in delineation of the mastoid antra, the semicircular canals, cochlea, and mastoid processes of the temporal bones. It has also been found to be an excellent view for visualization of the

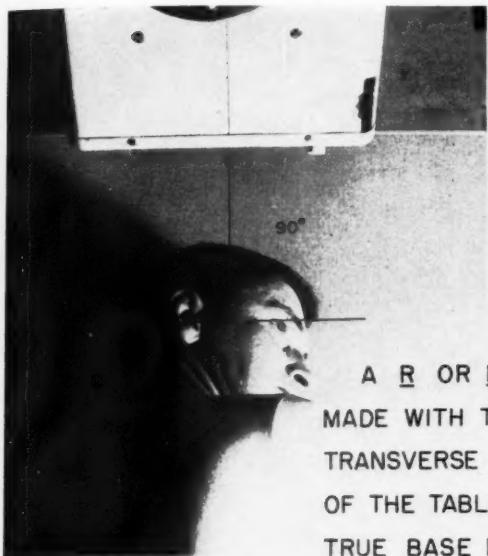


Fig. 1. Conventional anteroposterior oblique Chamberlain-Towne projection at approximately 35° according to the original description of Towne.

temporomandibular joints in the sagittal plane and for the zygomatic arches.

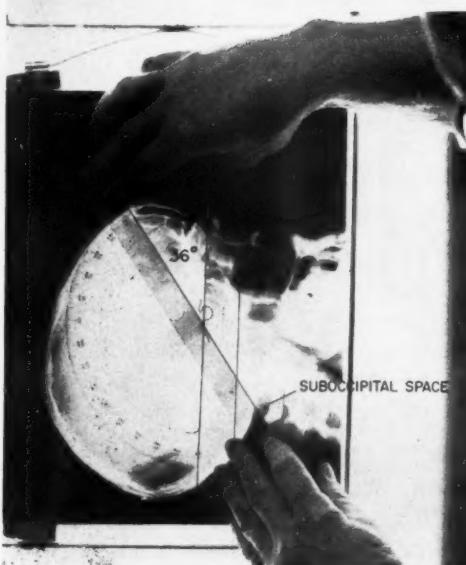
Frequently looked for, but seldom found in the routine 35°-angle projection have been the dorsum sellae and posterior clinoid processes if they are projected into the foramen magnum where they can be studied. Because of variations in the basal angles of different skulls, an exact determination of the angle of projection other than one of 35° becomes mandatory. In 100 routine examinations at our institution, with the anteroposterior oblique view, the dorsum sellae was found to be projected exactly into the foramen magnum in only about 26 per cent so that it could be studied in detail. In order to obviate this difficulty, a method of measuring was devised in which a lateral view of the skull was

¹ From the Radiological Service, Western Psychiatric Institute, and the Falk Clinic, School of Medicine, University of Pittsburgh, Pittsburgh, Penna. Presented at the Forty-sixth Annual Meeting of the Radiological Society of North America, Cincinnati, Ohio, Dec. 4-9, 1960.



1st

A R OR L LATERAL VIEW IS
MADE WITH THE CML EXACTLY
TRANSVERSE TO THE LONG AXIS
OF THE TABLE TO ESTABLISH A
TRUE BASE LINE.



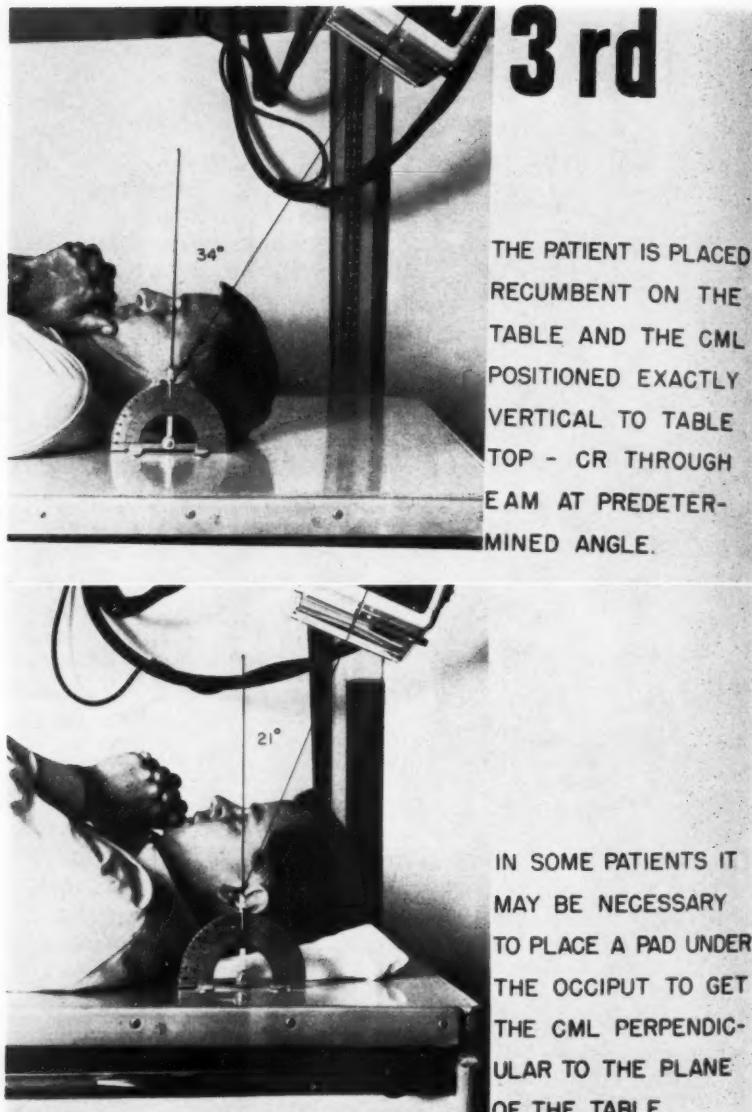
2nd

THE WET FILM IS HUNG
UP ON THE VIEW BOX
AND A VERTICAL LINE
SCRATCHED THROUGH
THE DORSUM SELLAE.
A SECOND LINE IS
SCRATCHED THROUGH
THE DORSUM SELLAE
TO THE POSTERIOR
ONE THIRD OF THE
SUBOCCIPITAL SPACE.
THE ANGLE OF PRO-
JECTION IS MEASURED
AT THE INTERSECTION.

Figs. 2 and 3. Measuring the angle of projection. CML. Canthomeatal line.

first made, with the canthomeatal line transverse to the long axis of the table (Fig. 2), and then, on the wet film, a perpendicular line was dropped through the dorsum sellae at right angles to the bottom of the film (Fig. 3). In order to measure the angle with a protractor, it is first

necessary to scratch this perpendicular line with a sharp knife and then, with a plastic ruler, point it to the posterior third of the suboccipital space, passing through the posterior arch of the atlas, where another line is scratched on the wet film. The predicted angle of projection is then



Figs. 4 and 5. Measuring the angle of projection. CML. Canthomeatal line. CR. Central ray. EAM. External auditory meatus.

read between the perpendicular and diagonal lines. In this manner, in a large percentage of cases, the dorsum sellae will be accurately projected into the middle of the foramen magnum as viewed in the anteroposterior oblique projection. It is necessary, of course, when making the radiographic exposure to have the can-

thomeatal line perpendicular to the longitudinal plane of the examining table so that the geometric situation present at the time of exposing the lateral film of the skull will be exactly reconstructed (Fig. 4).

The central ray is directed toward the nape of the neck through the external auditory meatus, which then corresponds

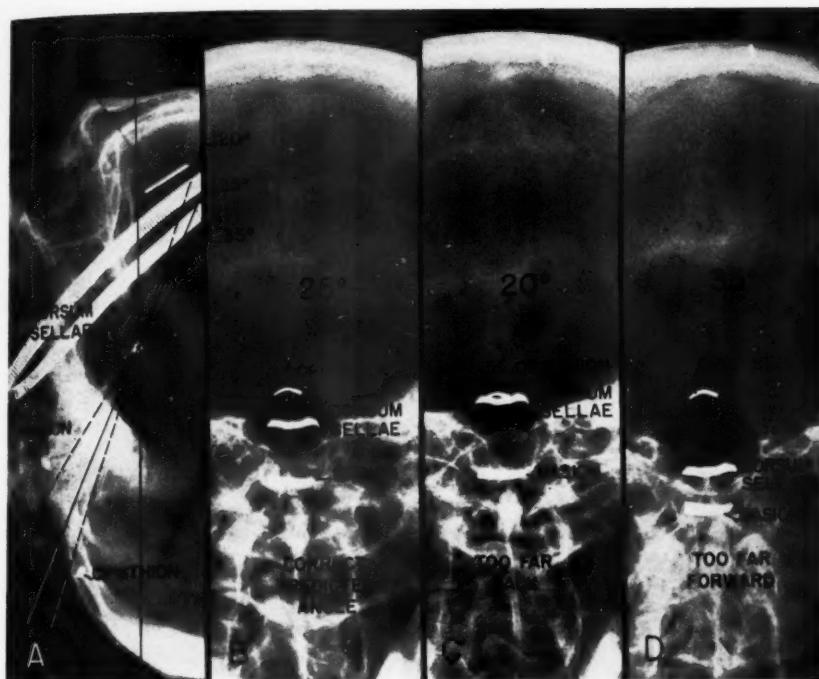


Fig. 6. Showing correct predicted angle of 25° and displacement of the sella cephalad with a small angle, caudad with a larger angle.

very closely with the suboccipital space through which the projection angle was determined. In some cases it may be necessary to place a pad under the occiput in order to get the canthomeatal line perpendicular to the plane of the table (Fig. 5).

An example of measuring these anatomic points is shown on the dry skull in Figure 6. Here, with lead markers in place, are shown the dorsum sellae, the basion, and the opisthion. The basion marks the anterior margin of the foramen magnum, and the opisthion the posterior margin. The perpendicular line is dropped from the top of the dorsum sellae and is parallel with the canthomeatal line as determined at the time of exposure of the lateral film (Fig. 6, A). The predetermined correct angle of projection is 25° (Fig. 6, B). If one reduces this angle to 20° (Fig. 6, C), the dorsum sellae will be displaced backward toward the opisthion and may be entirely covered by the occipital bone. If a larger

angle, 35°, is used (Fig. 6, D), then the dorsum sellae will be projected anteriorly and be hidden in the cervical vertebrae and/or beneath the basion. Another example of a predetermined angle in a living subject is shown in Figure 7. In this skull the correct angle determined is 30°, which projects the dorsum sellae directly into the mid-portion of the foramen magnum. A 25° angle displaces it cephalad over the occipital bone, and a 35° angulation displaces it caudad, as we have shown with the dry skull.

Still another example is shown in Figure 8, a lateral view of the skull with a predicted angle of only 21° and a basal angle of 133°. This is to be compared with another skull (Fig. 9) showing a predicted angle of 45°, at the upper end of the projection spectrum, and a basal angle of only 113°. It appears that the predicted angle of projection of the dorsum sellae is roughly inversely proportional to the basal angle, though exceptions occur. In gen-

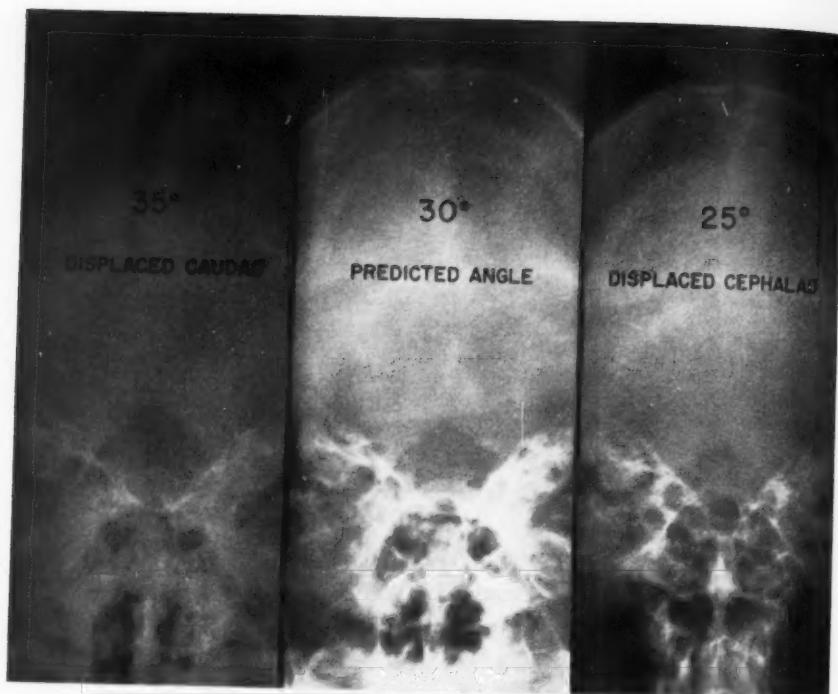


Fig. 7. Showing correct predicted ang'e of 30° for the dorsum sellae and displacement cephalad at 25° and caudad at 35° .

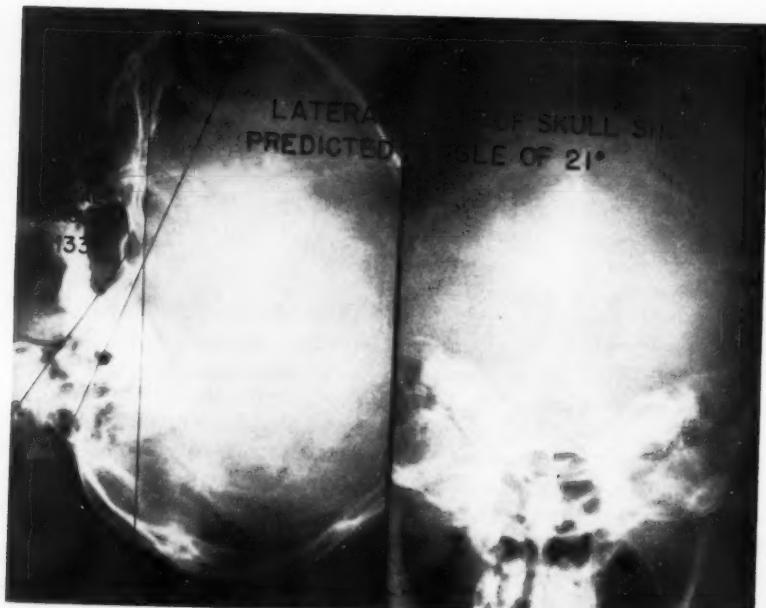


Fig. 8. Showing a very small normal predicted angle in a skull having a relatively wide basal angle.

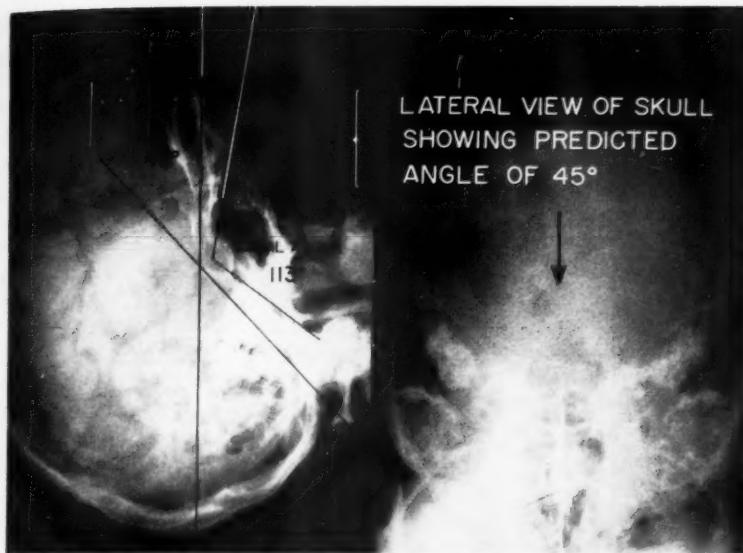


Fig. 9. Showing a large predicted angle in a skull having a relatively small basal angle.

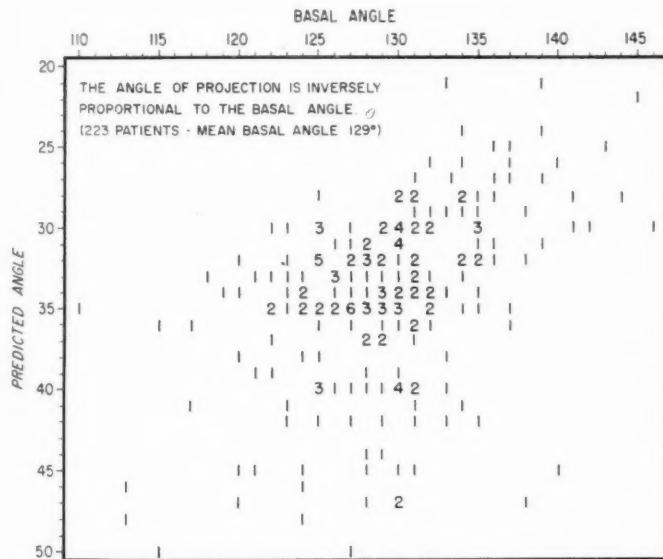


Fig. 10. Basal and predicted angles.

eral, the larger the basal angle the smaller will be the predetermined projection angle and the smaller the basal angle, the larger the predicted angle of projection (Fig. 10). In 223 patients the basal angles ranged from 120 to 135°, with a mean of 129°, and

in most instances the predicted angles fell between 30 and 37°.

For this technic, it is extremely important that we have complete patient co-operation, as demonstrated in Figure 11. With a group of 123 medical secre-

taries and nursing students, our percentage of successes by the method described was as high as 98 per cent. With psychiatric patients under treatment in the hospital, this percentage was reduced to 83. These latter patients did not, or could not, follow instructions exactly and would allow their

the feet in an anteroposterior oblique projection of the skull there will be shown, in most cases, a satisfactory profile of the petrous ridges. If one is concerned, however, with delineating the width or third dimension (3, 4) of the dorsum sellae and the sella turcica, it may be necessary to

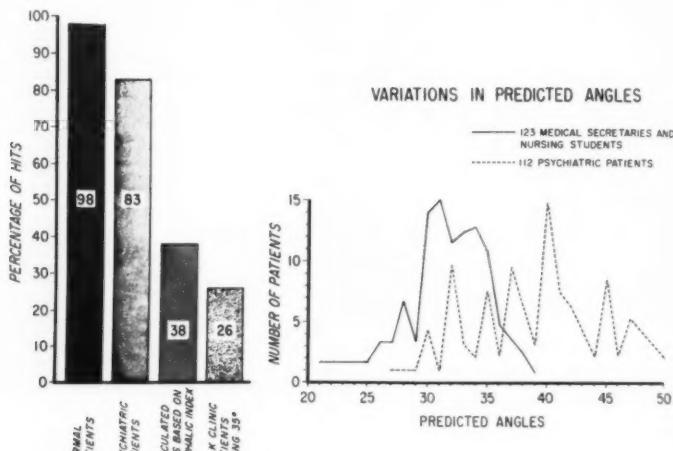


Fig. 11. Results of measurements in co-operative and non-co-operative patients.

heads to move upward instead of holding the chin down, or would open the mouth instead of keeping it closed with the hand holding the head down.

Angles of projection have been determined on the basis of the cephalic index (2), namely the greatest breadth of the cranium multiplied by 100, and divided by its length. With this method of calculating the projection angles in our material, the successes would have been only 38 per cent. Among the medical secretarial students and nursing students, the predicted angles fell principally between 30 and 35°; in psychiatric patients this range was much wider, all the way from 30 to 45°. No explanation for this is apparent. It is merely a recorded observation from which no conclusions are drawn.

SUMMARY

By use of a routine 35° angle toward

place these structures exactly in the foramen magnum where they can be studied in detail. By an application of these geometric principles one may, if he so wishes, displace this structure further cephalad or caudad.

ACKNOWLEDGMENT: The technical assistance of Lawrence C. Cross, R.T., in carrying out the experimental procedures is gratefully acknowledged.

Falk Clinic
University of Pittsburgh,
Pittsburgh, Penna.

REFERENCES

1. TOWNE, E. B.: Erosion of the Petrous Bone by Acoustic Nerve Tumor: Demonstration by Roentgen Ray. *Arch. Otolaryng.* **4**: 515-519, December 1926.
2. CAMERON, M. F.: Application of Cranial Measurements to the Chamberlain-Towne Projection. *M. Radiog. & Photog.* **29**: 2-5, 1953.
3. DI CHIRO, G.: The Width (Third Dimension) of the Sella Turcica. *Am. J. Roentgenol.* **84**: 26-37, July 1960.
4. FARIÑAS, P. L.: Value of X-ray Examination of the Sella Turcica in the Sagittal Positions. *Radiology* **32**: 411-415, April 1939.

SUMMARIO IN INTERLINGUA

Un Nove Technica pro le Accurate Projection del Dorso Sellar ad in le Foramine Magne

Le exposition conventional, i.e. antero-posterior oblique del cranio secundo Chamberlain-Towne, le dorso sellar se projice ad in le foramine magne de maniera que illo pote esser studiate adequaremente in minus que 30 pro cento del casos. In le presente communication un nove technica pro le projection del dorso sellar ad in le foramine magne es describite, prendente in consideration le variationes individual in le angulo basal del cranio. Un sol exposition lateral del cranio es obtenite con le linea cantho-meatal in perpendicularitate con respecto al axe longe del tabula roentgen. In le pellicula ancora humide un linea perpendicular es abassate a transverso le dorso sellar in rectangularitate con

le pede del pellicula. Iste linea es inscritte in le pellicula con un cultello affilate e dirigite alora al tertio posterior del spatio suboccipital, transversante le arco posterior del atlante, ubi un secunde linea es ingrattate. Le angulo inter le linea perpendicular e le linea diagonal es le predicite angulo de projection.

Le radio central es dirigite verso le nucha a transverso le externe meato auditori, lo que corresponde alora strictamente con le spatio suboccipital per le qual le angulo de projection esseva determinate.

Con iste technica, le procentage de successos in un gruppo de subjectos cooperative attingeva le alte cifra de 98.



Circulatory Arrest: Manual and Mechanical Means for Emergency Management¹

CHARLES T. DOTTER, M.D., KURT R. STRAUBE, M.D., and DOUGLAS C. STRAIN, B.S.²

DURING THE YEAR since Kouwenhoven, Jude, and Knickerbocker (1) introduced closed chest compression as a means for artificial circulation, many lives have been saved, including at least 3 at the institution from which this report comes. All such resuscitations have been in the relatively small group of patients whose primary defects eventually permitted an effective heartbeat, however paced. While proportionately small, the annual number of our countrymen dying of potentially reversible causes is approximately 100,000 (based upon the estimated number of sudden "mechanism" deaths from coronary disease). It follows that all should become familiar with the emergency management of circulatory arrest. General principles are well covered in Stephenson's monograph (2), and details of the closed chest technic have been published recently (3). A brief description follows.

MANUAL CLOSED-CHEST ARTIFICIAL CIRCULATION

Where resuscitation is indicated, circulatory arrest may be countered by posterior displacement and release of the precardiac chest wall, 60 to 100 times a minute. This is done with the patient supine, the heel of the operator's hand being used to push the lower sternum inward about 2 inches. Recoil is passive. The maneuver compresses the heart against the spine, with resulting ejection of blood, thus making use of the heart's valves in converting it to a passive pump powered by the operator. Effectiveness should be gauged by palpation of the peripheral pulses produced. Mouth-to-mouth artificial respiration is instituted immediately (intermittently if necessary; not at all if adequate sponta-

taneous respiration is present). Drug therapy and electrocardiographic diagnosis can be deferred until means for definitive therapeutic attempts are available. To the radiologist in private practice, this will generally entail emergency transfer of the patient to a hospital.

The foregoing method was used in a recent instance where death was delayed for two and one-half hours following total loss of left ventricular function due to massive myocardial infarction.

CASE I: A 38-year-old male was examined by contrast cardiovascular visualization prior to planned surgery for aortic valvular stenosis (Fig. 1). Two or three minutes following an injection of Hypaque into the proximal aorta, chest pain and the characteristic electrocardiographic changes of myocardial infarction heralded the onset of left heart failure and acute pulmonary edema. Ventricular tachycardia soon led to ventricular fibrillation. Closed chest artificial circulation and mouth-to-mouth artificial respiration were begun; electrical defibrillation was accomplished less than a minute following the onset of fibrillation. The patient was intubated and thereafter pulmonary ventilation was maintained by an anesthesiologist (who had been sought at the onset of chest pain). During the ensuing two and one-half hours, several persons successfully participated in the manual maintenance of the patient's circulation.

It became apparent that, while external electrical defibrillation was effective, the resulting cardiac contraction, though co-ordinated, was insufficient in strength to provide the coronary flow necessary for its own survival. Unless artificial circulation was maintained, ventricular fibrillation soon returned. When chest compression was stopped or ineffectively performed, the result was a pulseless, unconscious patient in ventricular fibrillation. Effectively applied, artificial circulation led to semi-consciousness, co-ordinated contraction (following electrical defibrillation), and aortic blood pressures which are in part shown in Figures 2 and 3.

The cardiologist (Dr. Herbert Griswold), cardiac surgeon (Dr. Albert Starr), and the radiologist agreed that cutting the stenotic aortic valve offered

¹ Work done in connection with this study was performed in the University of Oregon's Minthorn Memorial Laboratory for Cardiovascular Research through Radiology, aided by grants from the U.S.P.H.S. (H-3275, C31), the Oregon Heart Association, and the Mallinckrodt Chemical Works. Accepted for publication in April 1961.

² President, Electro Scientific Industries, Portland, Ore.

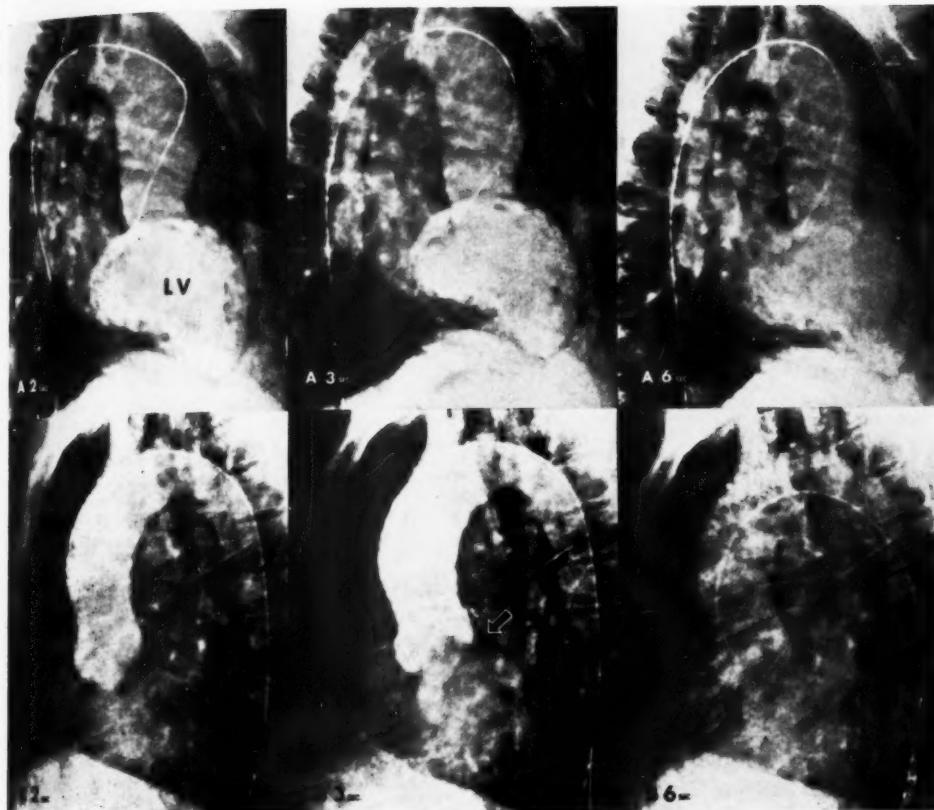


Fig. 1. Case I: Fatal myocardial infarction. A 38-year-old male studied because of rheumatic valvular disease.

A. Films two, three, and six seconds after initial left ventricular injection. The ventricle has appearance of perpetual diastole (see also Fig. 1, B). The electrocardiogram revealed only transient bigeminy. Contrast agent remained in the aorta throughout the study, a distinct abnormality.

B. Films two, three, and six seconds after aortic injection again disclose delay in progress of the injected medium and also reveal the presence of major proximal stenosis of the left coronary artery (arrow). Moderate aortic valvular insufficiency was demonstrated. Minutes later acute left heart failure developed and resuscitation was instituted. It was abandoned two and a half hours later, following ineffective aortic valvulotomy and demonstration of an infarcted, noncontractile left ventricle.

a chance of improvement, and this was subsequently accomplished in the radiology department. External chest compression was found to be effective even after the left pleural space had been opened widely. Advantage was taken of the opportunity to compare external *versus* direct cardiac massage. Aortic pressures due to direct cardiac massage by an experienced cardiac surgeon were recorded and in Figure 3 are photographically superimposed upon those resulting from the closed chest maneuver. In this instance at least, the latter was superior. Inspection of the heart revealed that, while the right ventricle contracted vigorously, the left was purple, quiescent, and leathery to the touch. Aortic valvulotomy was ineffective and artificial circulation was discontinued.

Autopsy revealed a massive anterolateral myo-

cardial infarction and a subtotal occlusion of the left coronary artery about an inch from its origin. It was thought that the infarction had occurred during the twenty-four-hour period prior to death. In any event, the clinical manifestations appeared to have been a consequence of the procedure.

Comment: Though the patient did not survive, this case afforded a dramatic demonstration of the usefulness of closed chest artificial circulation. Its simplicity and superiority over direct cardiac massage were likewise established. The episode also stimulated thought about the problem in general.

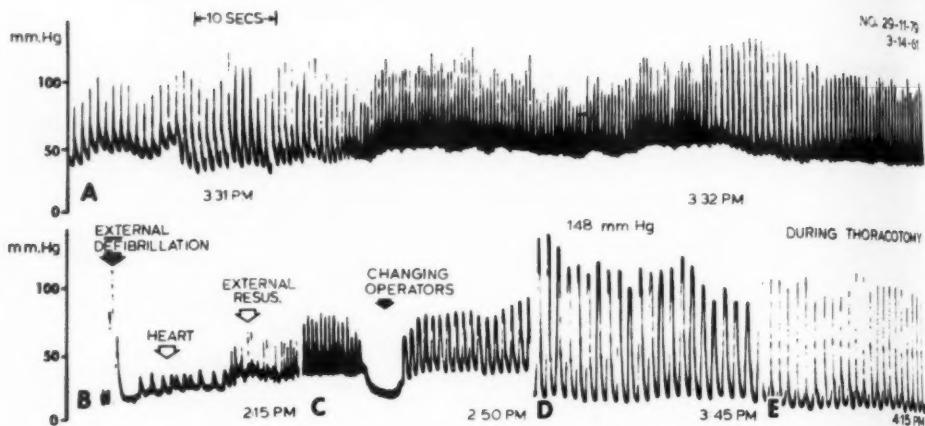


Fig. 2. Case 1: External artificial circulation. Tracings selected from continuous aortic pressure record made during resuscitation following acute left ventricular failure due to myocardial infarction. These were made at 2.5 mm. per second paper speed and identical sensitivity.

A. Despite variations in rate and amplitude, the resuscitator, a radiology resident, maintained good peripheral pulses and satisfactory coronary perfusion (judged by the electrocardiogram; not shown due to inevitable artifacts).

B. External defibrillation by Kouwenhoven's technic repeatedly resulted in co-ordinated but unfortunately ineffective ventricular rhythm.

C. Half an hour later: no ventricular pulses during a change of operators.

D. Wide pulse pressure and fairly high systolic levels attained by one operator.

E. Pressures from external thoracic compression during left thoracotomy (emergency aortic valvulotomy).

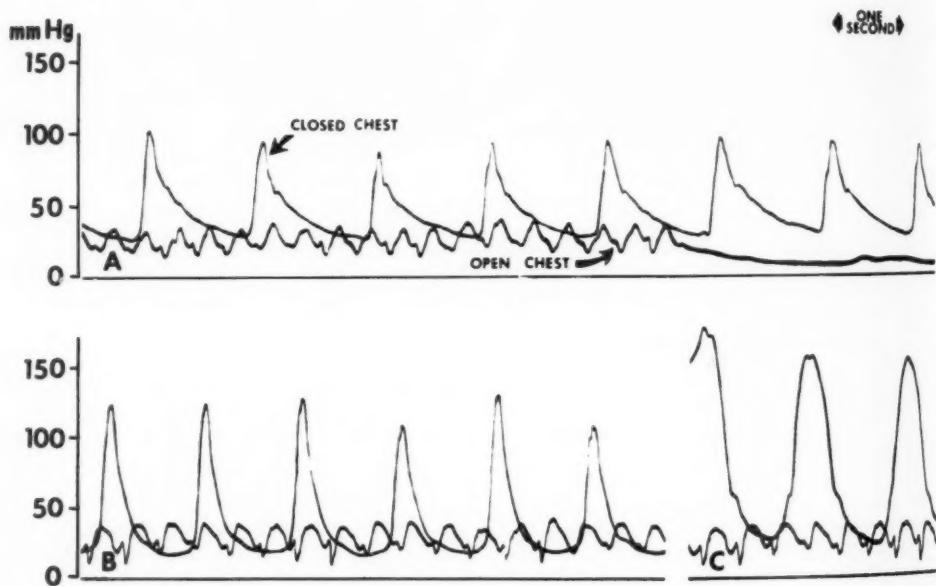


Fig. 3. Case 1: Comparison of aortic pressure pulses due to external artificial circulation with those of direct cardiac massage. Recorded at 25 mm. per second paper speed, same calibration.

A. Higher, slower pulse curve with a dirotic notch was achieved by external chest compression (radiologist). Lower curves on A, B, and C are photographically superimposed records of the results of a skilled thoracic surgeon performing manual cardiac massage at the time of emergency aortic valvulotomy.

B. Pressure records during closed chest circulation by a completely untrained laboratory technician. The lower trace is again that of relatively ineffective direct massage.

C. The highest levels achieved (resident in surgery). External massage was clearly superior to direct massage in this patient.

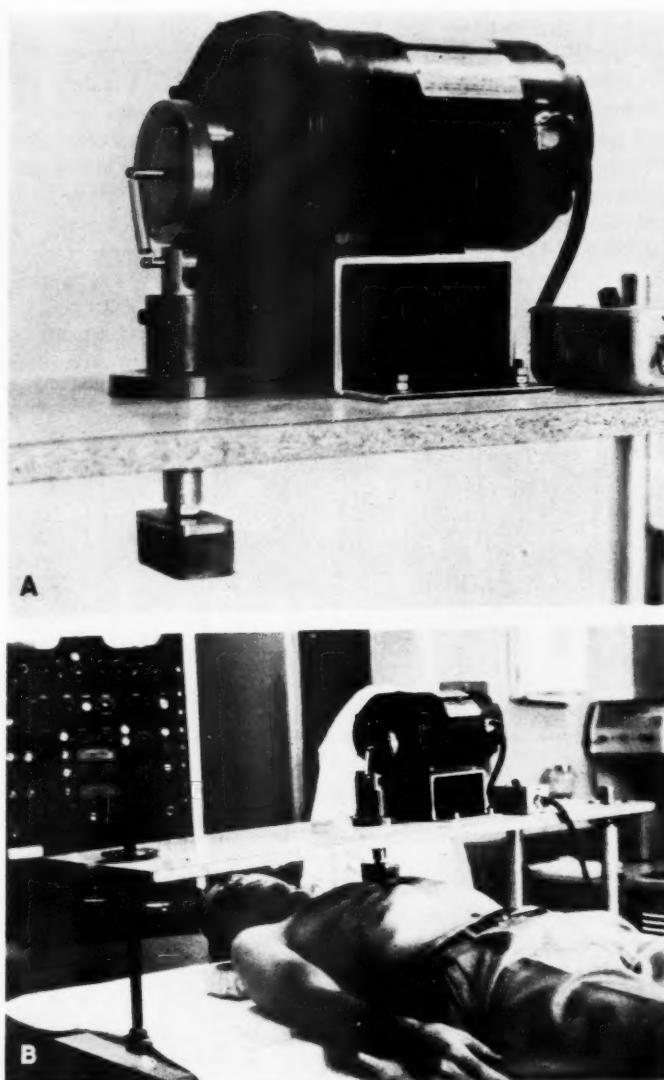


Fig. 4. The circulator. A. Electric motor (1/10 h.p.), cam, and thrust rod with rubber shoe which contacts patient's sternum. B. Simulated use photograph showing mechanical external artificial circulator. Patient lies between motor board and base of the external circulator. Height of motor board and therefore depth of thrust can be adjusted by jack-screw on vertical support shown at the left.

A DEVICE FOR MECHANICAL CLOSED CHEST ARTIFICIAL CIRCULATION

An anesthesia machine using room air is superior to chest compression for the purpose of artificial respiration. By analogy, even greater advantage should result from

the development of a mechanical device for compressing the heart through forced sternal depression. Furthermore, such a device would permit the study on cadavers of controlled variation of such parameters as the repetition rate and characteristics

of applied thrust. On the basis of experiences gained in the foregoing case, a simple machine was designed and constructed³ for this purpose.

The prototype artificial circulator consists of a thrust mechanism mounted on a supporting frame. The latter is rectangular in shape, hinged at both lower corners; it is rigidly joined at one upper corner and may be opened at the other for positioning purposes. The patient's back is placed on the baseboard. A jack-screw mechanism on one of the hinged vertical

measuring 2×4 inches. The instrument is pictured in Figure 4.

Initial trial of the device was made on an intact heparinized adult cadaver eight hours following death due to coronary artery disease. Polyethylene tubing was inserted into a femoral artery, 800 c.c. of tap water was injected to make up for postmortem loss in effective circulating blood volume, and pressures were recorded from the abdominal aorta during mechanical artificial circulation (Fig. 5). Both mechanical and manual chest compression

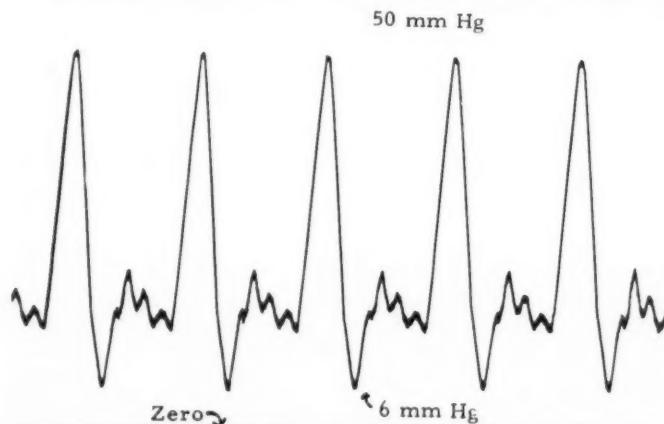


Fig. 5. Femoral blood pressure. Mechanical external artificial circulation in a heparinized cadaver eight hours postmortem. Pulse regularity is characteristic of a mechanical device.

members permits regulation of the distance between the upper and lower crossbars (motor support and baseboard respectively). This adjustment provides for setting both the level and the depth of thrust with reference to the patient's sternum. Experience soon indicated the desirability of adding a ridged rubber mat to the baseboard. A 1/10 h.p. electric motor, geared down to 60 r.p.m., is connected through a simple cam so as to impart a 2-inch regular reciprocal motion to a vertically positioned thrust bar, which extends downward through a hole in the motor board to bear upon the sternum through a rubber-padded pressure plate

were effective. Higher systolic peaks, though less well sustained, were obtained by the manual technic. An opportunity to test the unit in a more life-like situation soon arose.

CASE II: Five days following transurethral prostatectomy, a 75-year-old male was found on the floor, cyanotic and without perceptible pulse or respiration. Since the duration of his collapse was not known, closed chest artificial circulation and mouth-to-mouth breathing were instituted immediately. An electrocardiogram revealed ventricular fibrillation. The patient was moved to a bed and pulmonary ventilation was thereafter carried out by a skilled anesthesiologist. Attempted external defibrillation failed to produce sustained coordinated contractions of the heart.

Thirty minutes after the discovery of circulatory arrest, the artificial circulator was put into operation. Percutaneous femoral artery catheterization was used to position polyethylene tubing in the ab-

³ The artificial circulator was built in a remarkably short period of time in the shop of the Electro Scientific Industries, under the direct supervision of Mr. Robert Phillips.

dominal aorta. A representative pressure tracing recorded during the use of mechanical artificial circulation is shown in Figure 6. Unfortunately, the records do not permit comparison with the effects of manual chest compression. Though manual compression produced higher systolic arterial pressure peaks, the significant comparison between mean pressures was not obtained. Systolic pulses were observed in the femoral veins.

Thereafter, with several interruptions for repositioning (during which the manual method was used), the patient was maintained on the pump. Approximately forty-five minutes after the institution of mechanical artificial circulation and at least one hour

applied thrust and varying the rate. A smaller motor will be used. Cadaver flow-pressure studies will be made in order to determine optimum functional characteristics. If warranted, the changes indicated will be incorporated in the design of a third light-weight, low-cost unit. We have recently been informed indirectly that a similar effort is under way elsewhere. This is not surprising. If it is, we wish our colleagues well; if not, we hope and believe it soon will be.

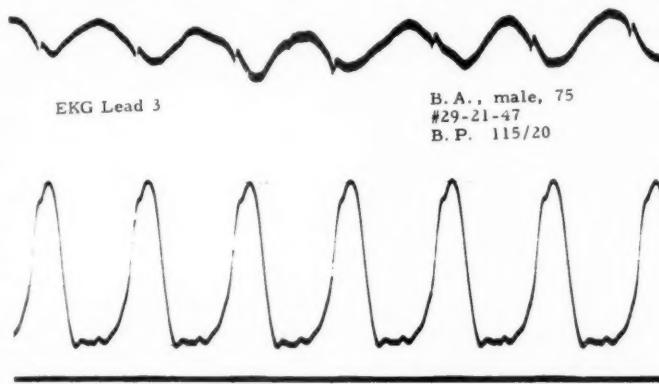


Fig. 6. Case II. Mechanical artificial circulation *in vivo*. The patient, a 75-year-old male, suddenly experienced ventricular fibrillation five days following transurethral prostatic resection. Pressure was recorded by means of polyethylene tubing percutaneously inserted into a femoral artery. At the time of the illustrated record, the patient was semiresponsive, though left ventricular function had been absent for approximately an hour.

and fifteen minutes after the onset of circulatory arrest, the patient, except for his heart, appeared viable. Although neither consciousness nor coordinated cardiac contraction had returned, there were reflex activity, random muscular movement, and ventricular fibrillation. These persisted until artificial circulation and respiration were discontinued.

Autopsy revealed diffuse coronary sclerosis without complete occlusion or evidence of myocardial infarction. Death was ascribed to ventricular fibrillation secondary to myocardial ischemia. Multiple rib fractures evidenced inexperience with, or limitations of, the methods employed. Intrathoracic and abdominal organs showed no evidence of trauma. Had the patient's collapse been discovered sooner, or possibly had the treatment been more effective, the outcome might have been different.

A second unit is planned. Provision will be made for adjusting the curve of

DISCUSSION

Ventricular fibrillation may be considered a mode of death rather than a primary cause. When it represents a by-product of sudden but temporary myocardial insult, such as a small infarct, an electrical shock, transient hypoxia, or the reaction to a contrast agent, prompt reoxygenation of the myocardium often permits successful defibrillation and recovery. As Kouwenhoven, Jude, and Knickerbocker have shown, both can be accomplished without the added risk of thoracotomy, thereby improving the patient's chances and increasing the scope of resuscitative efforts. On the other hand, regardless of how promptly and effectively

it is applied, artificial circulation cannot cause blood to flow through occluded coronary arteries, and defibrillation is not likely to succeed if persistent myocardial ischemia prevents the re-establishment of autogenous coronary perfusion. *In providing a temporary substitute for the heart which has failed, artificial circulation affords an opportunity to treat the basic disease after it has "killed" the patient—therapy without risk!*

Rhythmic, co-ordinated contraction of the human heart can be initiated several hours after death (4). The inability of the pathologist to time the moment, hour, or even the day of myocardial infarction gives negative support to the suspicion that protracted myocardial anoxia, though rendering the heart functionless, does not *per se* exclude the possibility of recovery following re-oxygenation. The moment when irreversible cell death occurs in human myocardial infarction is not clear. Comparing infarcts, the place and degree of myocardial ischemia may vary widely, while the resulting loss of function is indistinguishable. For this reason, re-oxygenation of the ischemic myocardium must be the basic rationale of the therapy of coronary disease. Vasodilators have failed. Anti-coagulants have been primarily prophylactic. Fibrinolysin shows promise only where fresh thrombi are involved in the occlusion. Surgery to date has been highly unphysiological (pericardial trauma, reversal in direction of myocardial blood flow, internal mammary ligation) or has failed by virtue of poor case selection and the technical difficulties inherent in the size and critical role of the coronary arteries. Where proximal localized disease is present, surgery nevertheless appears to offer the best chance for salvage. That its potential is as yet unrealized is understandable, since over half of those suffering from acute myocardial infarction survive despite therapy which is little more than supportive. With life already hanging in the balance, and recovery apparently possible until the moment of death, we are reluctant to subject patients

to diagnostic and therapeutic procedures of unproved value but high risk.

Regardless of how it is accomplished, the successful institution of artificial circulation within two minutes of "death" due to acute myocardial infarction will provide a second opportunity, one such that the boldest imaginable approach would be more conservative than none.

CONCLUSIONS

1. Closed chest artificial circulation is a simple and effective procedure with which all radiologists should become familiar.
2. A prototype mechanical device has been constructed and used for the purpose of artificial circulation in man.
3. Artificial circulation instituted at the moment of death from myocardial insufficiency makes possible the immediate application of a number of diagnostic and therapeutic techniques which previously have been regarded as radical. There is literally nothing to be lost—no risk—in this approach. The implications are obvious.

ADDENDUM

Since this paper was submitted we have successfully employed manual closed chest resuscitation in 2 patients undergoing left heart catheterization. In one, a 38-year-old male with mitral valve disease, heart failure led to asystole as a result of a prolonged run of ventricular tachycardia due to catheter irritation of the left ventricle. A normal sinus rhythm spontaneously returned following ten minutes of artificial circulation and mouth-to-mouth breathing. In the other patient, a 45-year-old female, ventricular fibrillation developed immediately on completion of a supravalvular injection of contrast agent. Resuscitative measures plus electrical defibrillation done six minutes after the onset of fibrillation were curative. Both patients were out of danger and fully conscious within twenty minutes of the onset of complication. Without the simple resuscitative techniques which were used, both would now be dead.

University of Oregon Medical School Hospital
Portland 1, Oregon

REFERENCES

- I. KOUWENHOVEN, W. B., JUDE, J. R., AND KNICKERBOCKER, G. G.: Closed-Chest Cardiac Massage. *J.A.M.A.* 173: 1064-1067, July 1960.

2. STEPHENSON, H. E.: Cardiac Arrest and Resuscitation. St. Louis, C. V. Mosby Co., 1958.

3. KOUWENHORVEN, W. B., JUDE, J. R., AND KNICKERBOCKER, G. G.: Heart Activation in Cardiac

Arrest. Mod. Concepts Cardiovas. Dis. **30**: 639-648 February 1961.

4. KOUNTZ, W. B.: Revival of Human Hearts. Ann. Int. Med. **10**: 330-333, September 1936.

SUMMARIO IN INTERLINGUA

Arresto Circulatori: Mesuras Manual e Mechanic in Tractamento de Urgentia

Compression del thorace claudite pote restablir le circulation post su arresto e provider un opportunitate pro le application immediate de mesuras therapeutic capace, possibilmente, a salvar le vita del paciente.

Es reportate duo casos. In un, le morte esseva retardate per duo horas e media post le perdita complete del function sinistro-ventricular causate per massive infarcimento myocardial. Le compression esseva applicate manualmente.

In le secunde caso, un dispositivo mechanic esseva usate. Isto consisteva de un mechanismo de impulso montate super un structura de supporto e activate per un motor electric de un decime cavallo.

Ben que ni le un ni le altere de iste duo pacientes superviveva, es opinate que le casos signala positive possibilitates del methodo. Le autores conclude que circulation artificial a thorace claudite es un simple e efficace procedimento e que omne radiologo deberea facer se familiar con illo.



Some Aspects of Pulmonary Dynamics Revealed by Concurrent Roentgen Kymography of Spirometric Movements and Diaphragmatic Excursions¹

ELLIOTT C. LASER, M.D.

UTILIZING a specially constructed grid, Goldenthal and his co-workers (1) in 1958 demonstrated that it was possible to obtain a good roentgen kymogram of the individual diaphragmatic excursions and that, furthermore, there appeared to be a correlation between the individual diaphragmatic movements in forced maximal expiration with the bronchspirometric ratings of each lung. In this paper, we plan to illustrate how this roentgen investigation of pulmonary physiology may be carried a step further to add information on the total vital capacity, the timed vital capacity, and expiratory flow rates.

Two years ago a simple apparatus was fashioned that has enabled us to obtain this additional data on respiratory dynamics. A special grid was constructed under the direction of Dr. Sumner Goldenthal, differing from the usual roentgen kymographic grid in the width of its lead strips and the spacing between the strips. The grid was designed to permit a recording of events during a time interval of four seconds over a strip of film measuring 30 mm. in width. It was in all respects similar to that described by Goldenthal, Armstrong, and Lowman. These authors found the dimensions of their modified grid (lead strips 30 mm. wide, spaced 1.0 mm. apart) "optimal for obtaining a maximum number of scanning points while simultaneously spreading out a single diaphragmatic excursion wave so that its amplitude and rate of rise could be measured with requisite accuracy." To obtain the additional information that we sought on respiratory dynamics, we simply rigged a conventional McKesson-Scott vital-capacity apparatus with a lead marker in

such a fashion that the marker rose synchronously with inflation of the bellows. The details of this modification are best noted in the accompanying illustrations (Fig. 1, A and B).

This modified apparatus resembles, to a degree, that devised by Wang and Shipley (2) to produce a similar curve on a convex paper strip. The lead marker was attached to the cover of the vital capacity apparatus by an aluminum tape. Since the cover of the apparatus rises in an arc, suitable plastic and metallic guides were constructed to enable the aluminum tape to follow a similar arc when the lid opened. At appropriate intervals in a vertical plastic strip linear metallic markers were embedded to indicate the number of liters of air that filled the bellows as the cover rose.

The kymographic grid was bolted to the outside surface of a Bucky diaphragm from which the standard grid had been removed. The whole assembly was then mounted in a vertical fashion, and an armature attached to the frame of the removed grid was designed to impart slightly over 3 cm. of movement to a film placed in the Bucky slot. At half-second intervals a rotating metal vane projected on the front surface of the kymogram apparatus marked off the time intervals. The spirometer was mounted on the superior surface of the kymogram assembly (Fig. 1, C and D) with the tube leading to the bellows at mouth level of the patient facing the cassette.

With this arrangement we were able to obtain concomitant tracings of diaphragmatic and spirometer movements. All examinations were made in a single max-

¹ From the Department of Radiology, University of Pittsburgh School of Medicine, Pittsburgh, Penna. Accepted for publication in January 1961.

Supported in part by a grant from the Pennsylvania Trudeau Society.

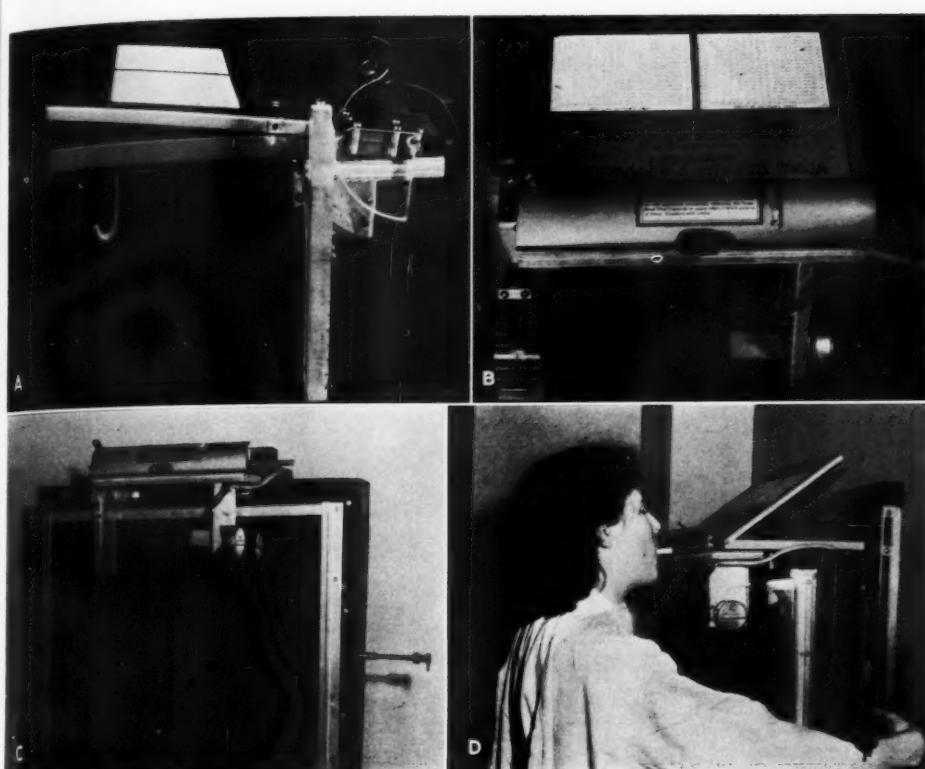


Fig. 1. A. Close-up lateral view of modified McKesson-Scott vital capacity apparatus. Note the metallic and plastic guides that have been attached to the cover of the apparatus near its hinged joint to guide the aluminum tape. The vertical plastic bar contains embedded lead volume markers on its flat anterior surface.

B. View of the modified vital capacity apparatus from the front. The aluminum tape with a horizontal lead marker at its lower end attaches to the left side of the apparatus. The cover has been lifted sufficiently to bring the marker to the 4-liter level. On the right under portion of the apparatus a rotating metallic vane (time-marker) is attached. This is turned by a small electric motor.

C. The vital capacity marking apparatus is seen mounted in correct position on the special roentgen kymogram assembly.

D. Appearance of the apparatus at the end of a forced expiration.

inal expiratory effort, in the same fashion as for a total vital capacity examination. The tracings, then, represent sequential changes in diaphragmatic position and air displacement from a starting point of maximal inspiration to maximal expiration. More than 300 examinations have been carried out in the past two-year period. Some of the more pertinent findings will be discussed and illustrated in the ensuing section.

ILLUSTRATIVE EXAMPLES

In the patient without pulmonary abnormality, the maximal diaphragmatic excursion occurred in the lateral and

posterior segments (Fig. 2, A and B). About 75 per cent of our patients with normal chests showed a 5 to 10 per cent greater diaphragmatic excursion on the left than on the right side. The kymographic curve of diaphragmatic movement in forced expiration did not always parallel the spirometer curve in shape and total excursion (Fig. 2, C, D, and E). It soon became evident that one cannot depend upon any absolute measure of diaphragmatic rise as an index of total vital capacity. Some persons with relatively limited total vital capacities showed considerably greater diaphragmatic excursions than did others with normal vital

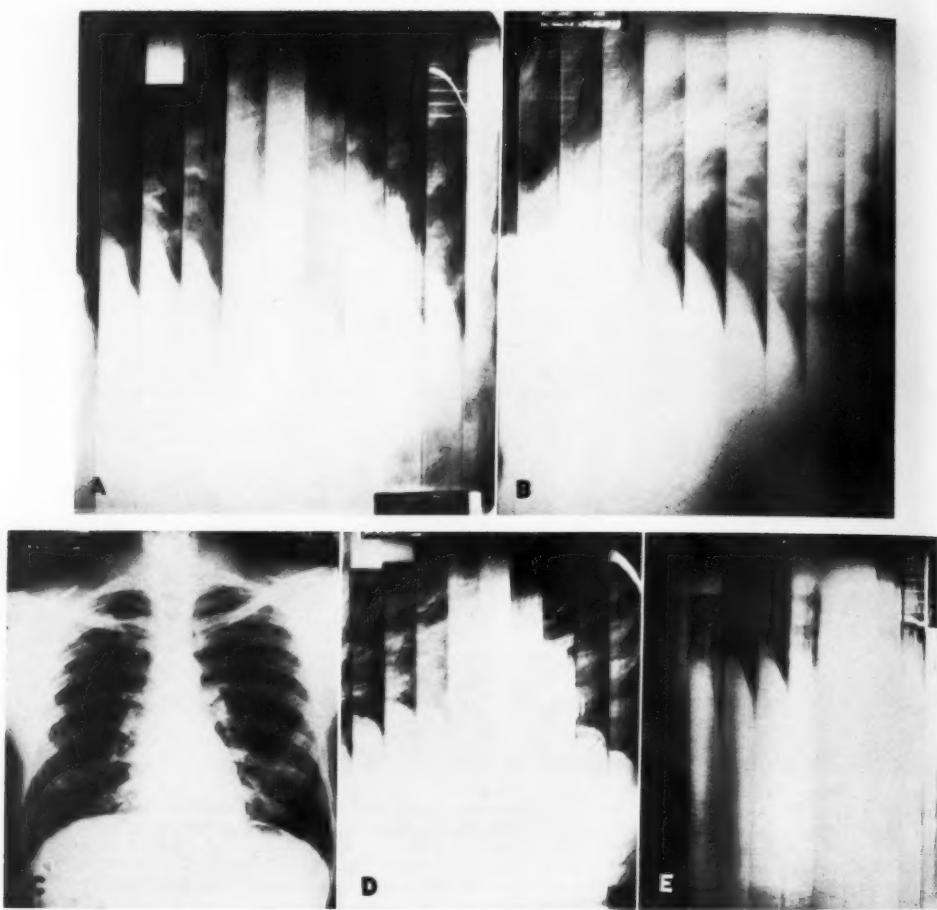


Fig. 2. A. Normal tracing. The vital capacity tracing is superimposed upon the left upper lung field. Each horizontal lead marker represents 1,000 c.c. of expired air. This patient has a vital capacity of approximately 4,200 c.c. The blips superimposed over the right upper chest represent half-second intervals. Both the one second and the total vital capacities are within the expected range of normal for this patient. Note the similarity of the diaphragmatic curves and the spirometer curve in form and total extent.

B. Lateral kymogram to illustrate the accentuated excursions of the posterior segments of the diaphragm. The vertebral column is on the right.

C and D. No demonstrable pulmonary abnormality. The diaphragmatic excursions are flatter than the spirometer curve.

E. Tracing made in a patient with a severe kyphoscoliosis and limited thoracic wall excursions. The major portion of the vital capacity in this patient can be attributed to his diaphragmatic movements, which do not bear any resemblance in curvature or total excursion to the spirometer tracing.

capacities. This discrepancy in relating the diaphragmatic curve and the spirometer curve must reflect, among other factors, the complexity of the mechanisms of respiration and the great variability in body build.

Abnormal elevations of the diaphragm, such as are encountered in eventration and in association with enlargement of the

underlying spleen or liver, gave rise to alterations in the ipsilateral diaphragmatic curve. Figure 3 illustrates a considerable flattening of the expiratory diaphragmatic curve on the left in a patient with leukemia, an enlarged spleen, and slight secondary elevation of the left hemidiaphragm. Figure 4 shows initial paradox motion followed by reduced total excursion

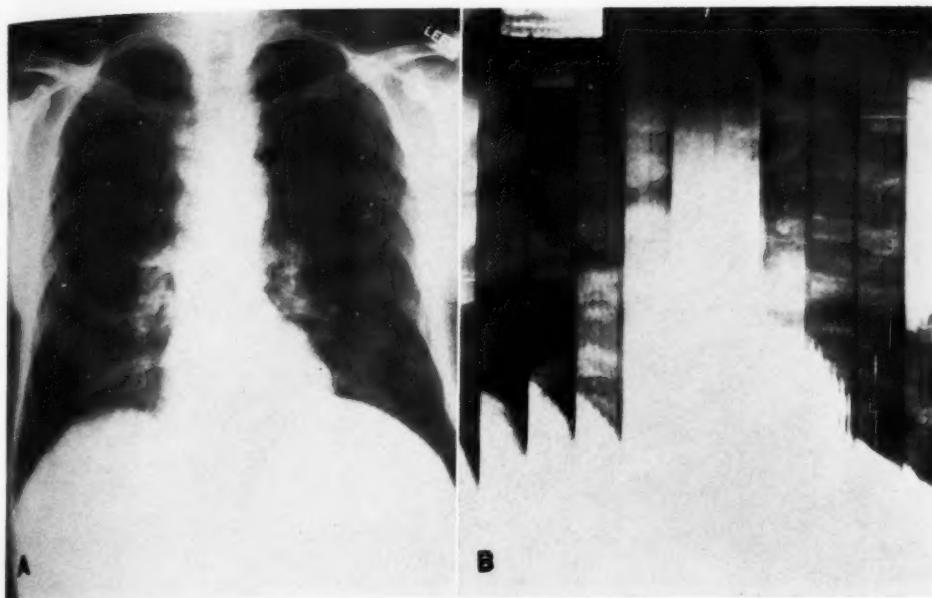


Fig. 3. A. Leukemia. Enlargement of mediastinal and hilar nodes and of the spleen. B. Flattened excursion of the left hemidiaphragm thought to be secondary to enlargement of the underlying spleen.

of the right diaphragm in a patient with an enlarged liver containing metastatic tumor. Figure 5, A and B, illustrates the characteristic pattern of diaphragmatic ascent in instances of eventration of the left and right diaphragms respectively. It is to be noted that only the initial segment of the involved diaphragmatic excursion is paradoxical, and that the curve becomes normal in direction but reduced in extent at about the same time that the spirometer begins to rise. In quiet respiration the eventrated diaphragm may show a completely paradoxical motion. However, in the forced expiration that takes place under the circumstances of this examination, active expulsion of air from both lungs, by whatever combination of mechanisms, dictates that the major movement of the involved diaphragm be in the same vertical direction as the exiting gas in the trachea.

In lobar collapse the ipsilateral diaphragm showed a normal directional, slightly flattened, and diminished curve in comparison to the unininvolved side. Atelectasis of the left upper lobe (A) and of the right upper lobe (B) is illustrated

in Figure 6. In both instances, the collapse is secondary to endobronchial carcinoma. Postoperative atelectasis of the



Fig. 4. Enlarged metastatic liver. Note the initial paradoxical motion of the right hemidiaphragm followed by a diminished total excursion on this side. Normal excursion on the left side.

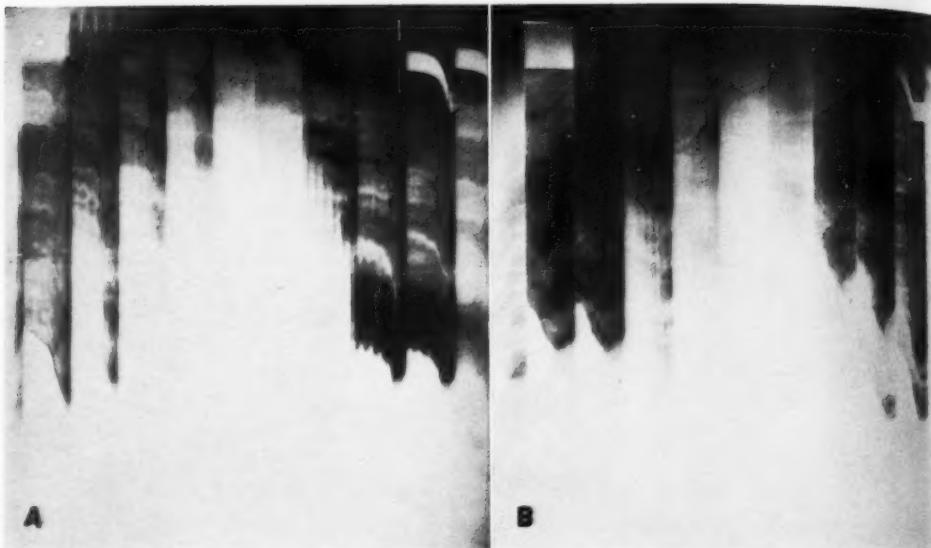


Fig. 5. A. Eventration of the left hemidiaphragm. At the onset of expiration there is an initial paradoxical movement of the left hemidiaphragm followed by a diminished total (normal directional) movement.

B. Eventration of the right hemidiaphragm. An initial paradoxical motion is noted on the right in this instance.

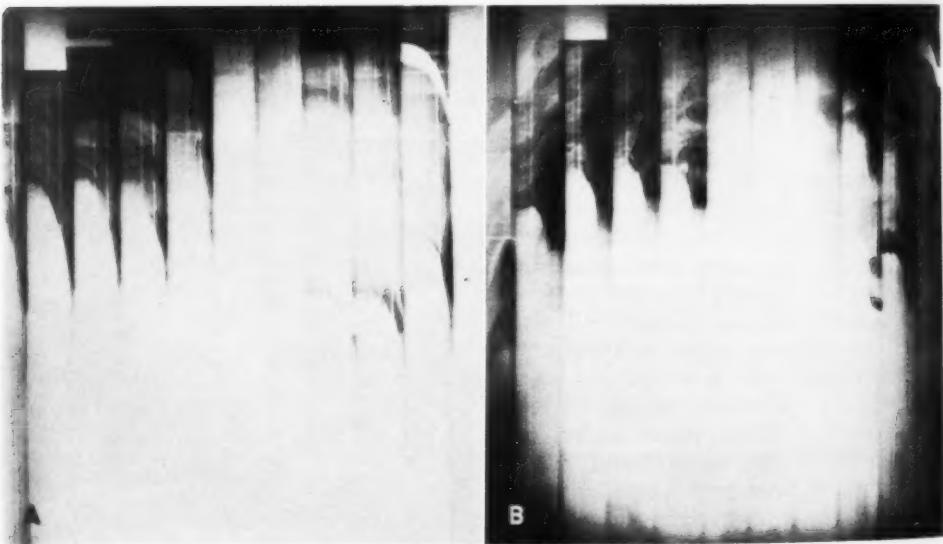


Fig. 6. A. Bronchogenic carcinoma with atelectasis of the left upper lobe. Note the diminished excursion of the left hemidiaphragm.

B. Bronchogenic carcinoma of the right upper lobe. The diminished excursion is noted on the right. The appearance of the diaphragmatic curve is otherwise not remarkable.

left lower lobe, relenting after conservative therapy, is illustrated in Figure 7, A-D. With collapse of the left lower lobe, the diaphragm on the involved side (judged by

movement of an air-fluid level in the underlying stomach) showed a flattened, diminished curve. On the following day, with almost complete re-expansion, the

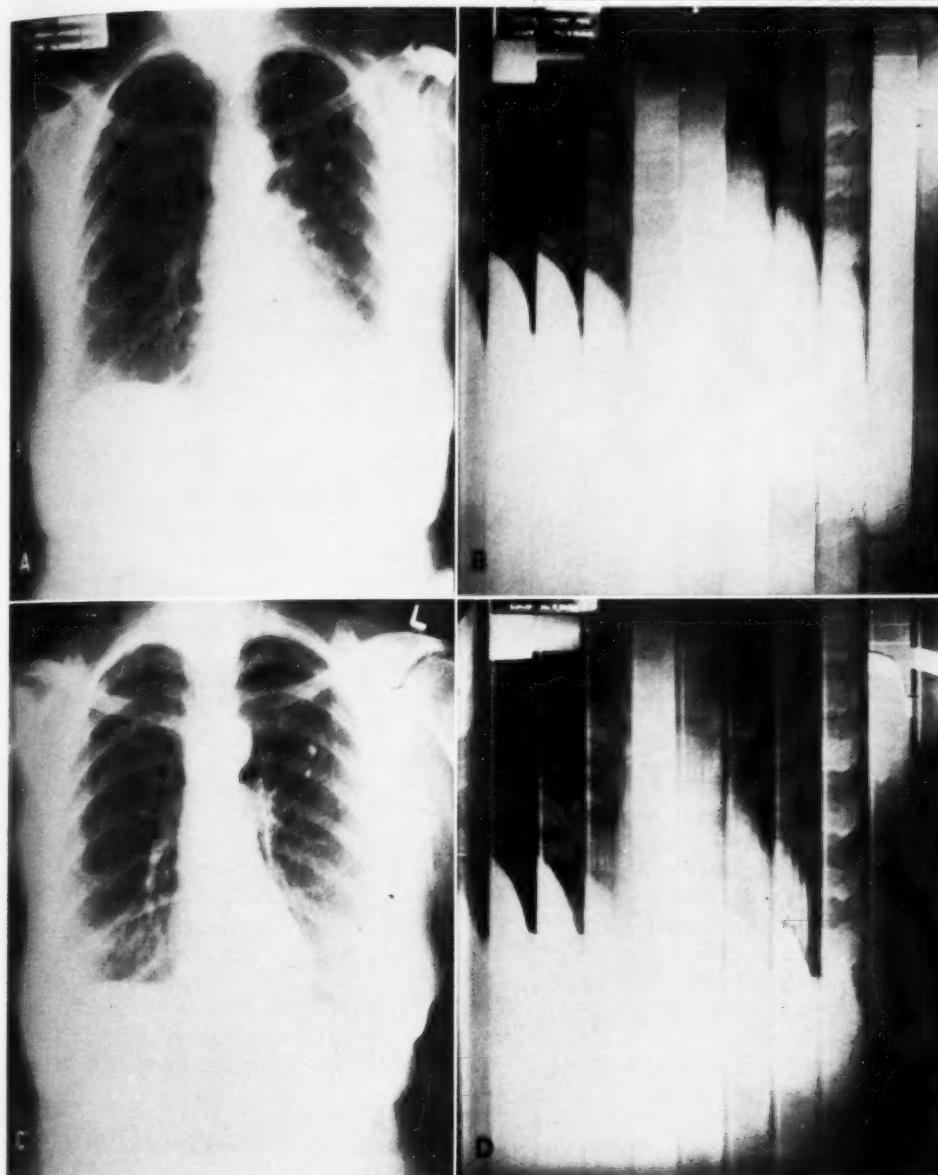


Fig. 7. A. Atelectasis of the left lower lobe one day following iliac endarterectomy.
 B. Postoperative left lower lobe atelectasis. The flattened curve of the left hemidiaphragm has been penciled in near the lower portion of the heart shadow.
 C. Left lower lobe atelectasis has almost completely cleared.
 D. Considerable improvement of the left diaphragmatic excursion is now evident. The somewhat irregular curve (penciled in black) on the left may be due to residual "sticky" parenchyma. There has been some improvement in total vital capacity.

under-
 ed, di-
 g day,
 n, the

diaphragmatic rise appeared steeper and more complete on the kymographic study. The somewhat irregular curve of the left

diaphragm on the second study may reflect incomplete peripheral re-expansion or "sticky" parenchyma.

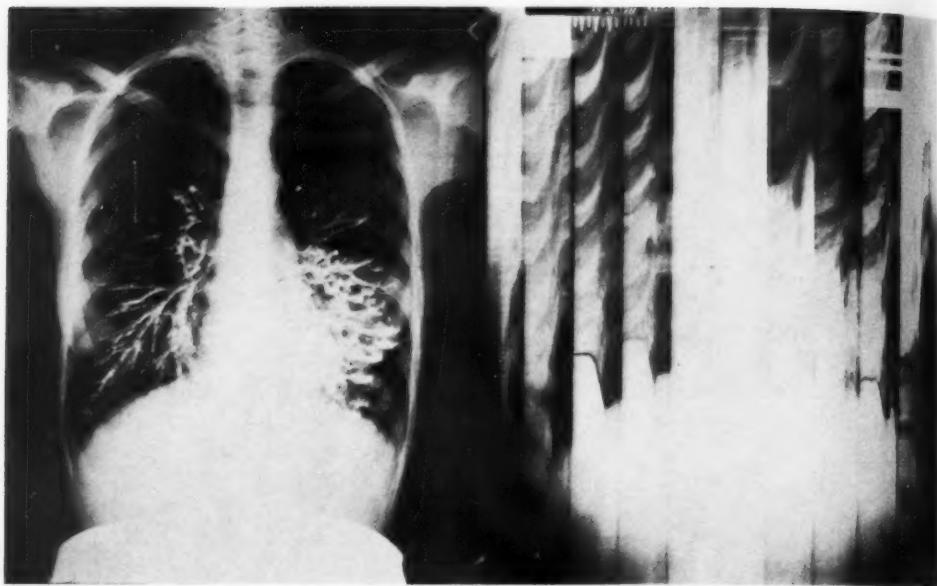


Fig. 8. Diminished excursion of the left hemidiaphragm in patient with cystic bronchiectasis of the left lower lobe. The similarity of the slope of both diaphragmatic excursions suggests the absence of air trapping.

Chronic inflammatory or granulomatous foci in one lung produced the expected alteration in diaphragmatic expiratory excursion, namely, a diminished ipsilateral ascent. Unless considerable secondary emphysema had developed, the rate of ascent (slope) usually approximated the contralateral diaphragm (Fig. 8).

Generalized pulmonary emphysema with air trapping resulted in flattened expiratory diaphragmatic curves that paralleled the spirometric excursions. Both in turn reflected the slow but sustained expiratory effort characteristic of this circumstance (Figs. 9 and 10). Localized pulmonary emphysema, when basilar in character, and particularly in the presence of a bleb, produced an abrupt cessation of an otherwise normal appearing diaphragmatic excursion on the involved side (Fig. 11).

Spirometric tracings carried out in 15 patients before and after bronchography with aqueous Dionosil showed an average immediate fall in total vital capacity approximating 45 per cent. No attempt was made to determine the duration of the lessened values. In this same group, one could observe ascent of the entire opacified

tracheobronchial tree on expiration rather than paradoxical respiratory motions of the upper and lower lobes, as previously reported (3).

Analysis of the entire group of patients studied by this special kymographic technic showed considerable unpredictable asymmetry of thoracic cage movements in one hemithorax compared to the other. While the lower rib movements were greater in degree than the upper rib excursions, there was no clear-cut evidence of any variation in the time of onset of rib movements at one level in comparison with another, as suggested by the employment of other technics (4).

DISCUSSION

For the first correct description of the anatomy of the diaphragm, we are indebted, according to Ballon (5), to Vesalius, and for recognition of the fact that its action is concerned with respiration, to Galen.

The diaphragm is attached posteriorly to the lumbar vertebrae, laterally to the lower six ribs, and anteriorly to the ensiform cartilage of the sternum. From these points of attachment the muscle fibers

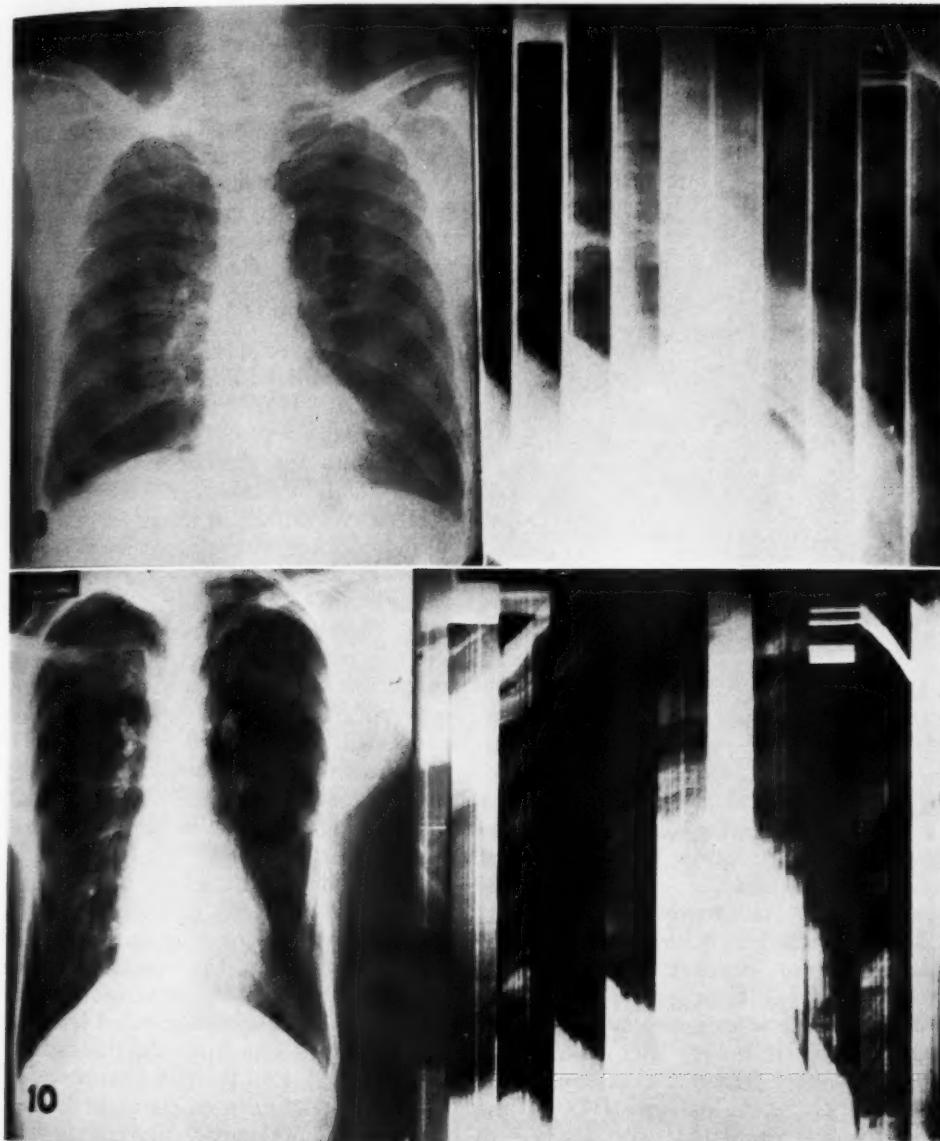


Fig. 9. Chronic bronchitis. Some emphysematous changes with flattening of both hemidiaphragms is apparent. Note the similar flattening of the diaphragmatic excursions and the spirometer tracing. A prolonged expiratory effort is characteristic of air trapping.

Fig. 10. Chronic asthma. The appearance of the chest suggests a considerable degree of emphysema. Prolonged expiration is apparent in both the spirometer tracing and the diaphragmatic excursions. The total vital capacity was normal for this patient, but the one-second vital capacity was low.

of the
debated.
us, and
ction is
1.
sorily to
to the
e ensi-
n these
fibers

sweep upward, arching toward the midline to join the central tendon, at which point the pericardium is attached. The dome of the diaphragm is otherwise free, moving downward and somewhat forward with

muscular contraction. The diaphragm is the chief muscle of respiration; its movements being responsible during deep breathing for 60 per cent of the total amount of air breathed (6).



Fig. 11. Localized basilar emphysema on the right. Note the sudden flattening of the right diaphragmatic excursion in an otherwise normal-appearing tracing. Timed and total vital capacity were normal.

Quiet inspiration is accomplished by contraction of the diaphragm and the external intercostal muscles. Quiet expiration involves no active muscular contraction. With deeper breathing, on the other hand, the thoracic expiratory muscles and abdominal wall musculature begin to contract actively to hasten the emptying of the lungs and to make it more complete (7).

The total diaphragmatic surface is about 270 sq. cm. A descent of 1.0 cm. will therefore increase the thoracic capacity by 270 c.c. and allow a corresponding volume of air to enter the lungs. In forced expiration the average maximal excursion of the right diaphragm is 6.6 cm. (1). If the same average excursion were applied to both diaphragmatic leaves, forced expiration would lead to expulsion of 1,782 c.c. of air by diaphragmatic motion alone. The other 40 per cent of total vital capacity then would be derived from the non-diaphragmatic portions of the respiratory maneuver. There is no question that either the costal respiratory mechanism or the diaphragmatic respiratory mechanism alone can meet the resting require-

ments for pulmonary ventilation. Recently, Robin and his co-workers (8) studied a group of patients with rheumatoid spondylitis and almost complete restriction of chest wall movements. They concluded that it is unlikely that complete rigidity of the bony thorax could reduce vital capacity by much more than 45 per cent. All of these findings emphasize the important place that diaphragmatic movements occupy in the respiratory mechanism.

The value of a tracing of forced expiration has been adequately documented (1, 2, 10, 11). Previous attempts at simultaneous study of diaphragmatic movements and pulmonary air flow were carried out by concurrent observations of electromyographic tracings of the diaphragm along with spirometry (4) or by fluoroscopic control of a mechanical diaphragmatic tracker along with spirometry (9). Neither method would seem to provide as reliable a correlation of diaphragmatic motion, rib motion, and air flow as was obtained by the present simple arrangement.

As was pointed out earlier in this paper, one cannot depend on any absolute measure of diaphragmatic rise as an index of total vital capacity; hence the value of the distinct spirometer tracing. A comparison of the curves of the individual diaphragmatic leaves may provide further valuable information about the contribution from each hemithorax. Previous roentgen studies of the diaphragm have failed to include the significant timed or total vital capacity reading (1, 3, 12-14). We have not as yet had an opportunity to correlate the individual diaphragmatic movements with bronchspirometric tracings from each side, but the work of Goldenthal and his associates (1) suggests that there is a statistical correlation between the percentage ventilation of each lung noted by this method and the more discrete pulmonary function tests.

Most authors are in agreement that normally there is a greater excursion of the left hemidiaphragm than the right.

This has been variously attributed to the difference in total volume between the right and left lungs (10 to 8.5) and to the fact that on the left the gastric air bubble offers less resistance than the liver on the right (14).

SUMMARY

1. A simple method of obtaining roentgen kymographic tracings of the diaphragmatic excursions and the timed and total vital capacity determinations in a single forced expiration has been described.

2. The clinical value of these three separate tracings registered on a single film has been emphasized.

3. Alterations in diaphragmatic excursion secondary to loss of diaphragmatic tone, enlargement of the liver or spleen, inflammatory and atelectatic changes in the lungs, and localized and generalized pulmonary emphysema have been described.

4. Examinations carried out before and after bronchography have indicated a rather significant drop in vital capacity immediately following this procedure and have emphasized the need for caution when it is contemplated in persons with borderline pulmonary reserve.

NOTE: The author gratefully acknowledges the help of Richard Granke, B.S., who aided in the design and construction of the modified vital capacity apparatus.

Presbyterian University Hospital
Pittsburgh 13, Penna.

REFERENCES

1. GOLDENTHAL, S., ARMSTRONG, B. W., AND LOWMAN, R. M.: Roentgen Studies of Ventilatory Dysfunction: An Analysis of Diaphragmatic Movement in Obstructive Emphysema. *Am. J. Roentgenol.* **79**: 279-292, February 1958.
2. WANG, R. I. H., AND SHIPLEY, R. E.: Simple Instrument for Evaluating Pulmonary Ventilatory Function. *J.A.M.A.* **167**: 1730-1733, Aug. 2, 1958.
3. SCOTT, W. G., AND MOORE, S.: Roentgen Kymography of Respiratory Movements of Thorax, Diaphragm, Lungs, Bronchi, and Mediastinal Structures. *Am. J. Roentgenol.* **37**: 721-732, June 1937.
4. KOEPKE, G. H., SMITH, E. M., MURPHY, A. J., AND DICKINSON, D. G.: Sequence of Action of the Diaphragm and Intercostal Muscles During Respiration. I. Inspiration. *Arch. Phys. Med. & Rehabil.* **39**: 426-430, July 1958.
5. BALLON, H. C.: An Historical Consideration of the Diaphragm. *J. Thoracic Surg.* **10**: 576-589, June 1941.
6. BEST, C. H., AND TAYLOR, N. B.: The Physiologic Basis of Medical Practice. Baltimore, Williams & Wilkins Co., 1943, p. 496.
7. BARD, P. (editor): McLeod's Physiology in Modern Medicine. St. Louis, C. V. Mosby Co., 9th ed., 1941, pp. 538-541.
8. ROBIN, E.: Personal communication.
9. WADE, O. L., AND GILSON, J. C.: The Effect of Posture on Diaphragmatic Movement and Vital Capacity in Normal Subjects with a Note on Spirometry as an Aid in Determining Radiological Chest Volumes. *Thorax* **6**: 103-126, June 1951.
10. FRANKLIN, W., MICHELSON, A. L., LOWELL, F. C., AND SCHILLER, I. W.: Clinical Value of Tracing of Forced Expiration (Expirogram). *New England J. Med.* **253**: 799-808, Nov. 10, 1955.
11. COMROE, J. H., JR., FORSTER, R. E. II, DUBOIS, A. B., BRISCOE, W. A., AND CARLSEN, E.: The Lung: Clinical Physiology and Pulmonary Function Tests. Chicago, The Year Book Publishers, Inc., 1955, p. 113.
12. PANCOAST, H. K.: Roentgen Ray Studies of the Functional Alterations of the Diaphragm. *New York M. J.* **111**: 353-355, Feb. 28, 1920.
13. EPSTEIN, B. S.: Roentgen Kymography of the Diaphragm. *Am. J. Roentgenol.* **74**: 70-85, July 1955.
14. SCHINZ, H. R., BAENSCH, W. E., FRIEDL, E., AND UEHLINGER, E.: Roentgen-Diagnostics. Volume III, Thorax. New York, Grune & Stratton, 1953, pp. 2703-2713.
15. BALDWIN, E. DE F., COURNAND, A., AND RICHARDS, D. W., JR.: Pulmonary Insufficiency; Physiological Classification, Clinical Methods of Analysis, Standard Values in Normal Subjects. *Medicine* **27**: 243-278, September 1948.

SUMMARIO IN INTERLINGUA

Certe Aspectos del Dynamica Pulmonar, Revelate per Roentgeno-Kymographia Simultanea de Movimentos Spirometric e Excursiones Diaphragmatic

Per medio de un modificate grillia roentgeno-kymographic e un spirometro attachate a illo, registrationes esseva obtinente representante le alteraciones sequential in le position diaphragmatic e le capacitate vital total e temporalmente determinate in le curso de un sol expiration fortiate. Es sublineate le valor clinic de

iste tres registrationes in un sol pellicula.

Esseva trovate que le curva kymographic del movimento diaphragmatic non esseva semper in parallela con le registration spirometric in conformatio e excursion total e, per consequente, non poteva esser acceptate con confidentia como un indice del total capacitate vital.

In le absentia de anormalitates pulmonar, le maximo del excursion diaphragmatic occurreva in le segmentos lateral e posterior, con un marcata tendentia de preponderar al sinistra in comparation con le latere dextere.

Alterationes in le excursion diaphragmatic esseva observe secundari al perdita de tono diaphragmatic, a allargamento de hepate o splen, a alterationes inflammatori

o atelectatic in le pulmones, e a emphysema localisate o general.

Examines effectuate ante e post bronchographia indicava un satis significative reduction del capacitate vital immediate mente post le execution del manovra. Isto signala, le necessitate de proceder caute mente si le manovra es contemplate in le caso de patientes con reservas pulmonar de adequatia insecur.



The Lower Urinary Tract in Infants and Children¹

LAWRENCE A. DAVIS, M.D., ROBERT LICH, M.D., LONNIE HOWERTON, M.D., and WILLIAM JOULE, M.D.

URINARY TRACT infection is extremely common and in pediatric practice such infections occurring repeatedly are generally considered an indication for excretory urography. In many instances, if the urogram is normal, the diagnosis is "cystitis" or "pyelonephritis," and only medical measures are prescribed. *A normal excretory urogram, however, does not*

bladder neck and a complete study of the urinary tract in patients with continuously infected urine must include a voiding cystourethrogram. This examination is the most efficient method of demonstrating obstructions in the bladder neck and urethra, and of analyzing the competency of the ureterovesical junctions. In many respects, its importance equals that of the

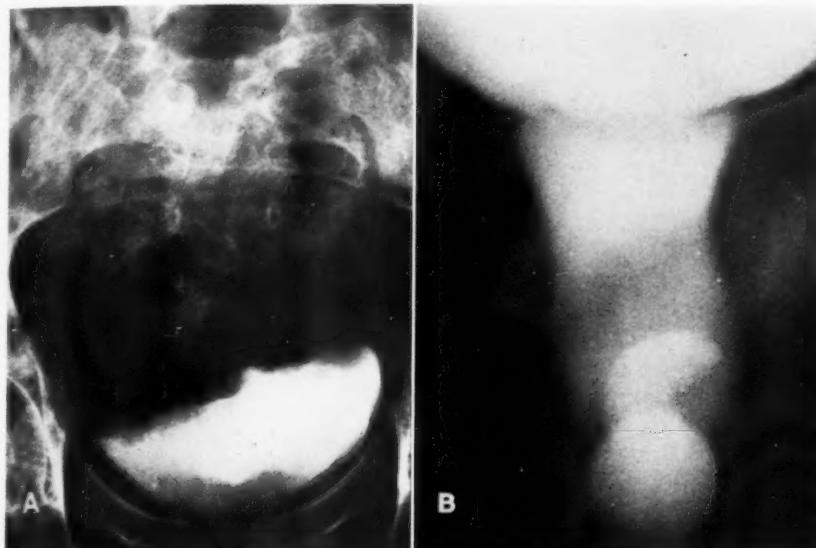


Fig. 1. P. H., seven-year-old male.

A. Detail from an excretory urogram. Normal appearing bladder in a patient with a history of previous left nephrectomy for "hydroureterosis." The right side is obstructed.

B. Voiding cystourethrogram showing tremendous urethral dilatation. This is secondary to bladder neck and meatal obstruction.

exclude urinary tract obstruction, particularly in patients in whom serious damage has not resulted. "Pyelonephritis" is a diagnosis of exclusion in infancy and childhood, and until urinary tract obstruction has been ruled out by all possible means, the patient has not been adequately investigated (1, 2).

Cystoscopy is relatively ineffective in evaluation of the posterior urethra and the

excretory urogram in urinary tract studies in infants and children (Fig. 1).

TECHNIC

There are many satisfactory methods of performing voiding cystourethrography (3-5). The basic gain, from the radiologist's point of view, is the detection of morphological abnormality. Physiologic findings are of secondary importance.

¹ From the Departments of Radiology and Urology, The University of Louisville Medical School and the Children's Hospital, Louisville, Ky. Presented at the Forty-sixth Annual Meeting of the Radiological Society of North America, Cincinnati, Ohio, Dec. 4-9, 1960.

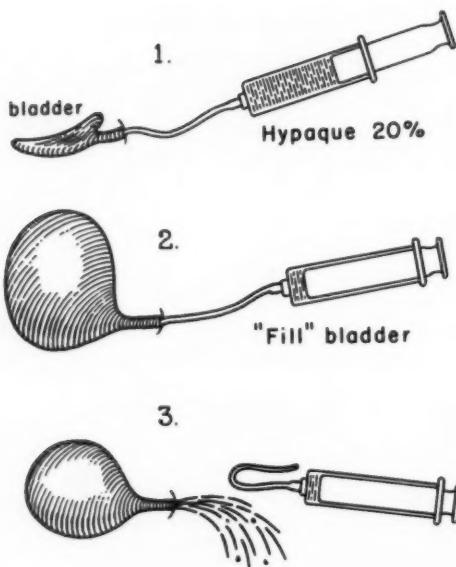


Fig. 2. Technic for performing voiding cystourethrography.

The voiding cystourerogram should be obtained following the excretory urogram or retrograde pyelogram, since the detection of ureteral reflux will be impossible if the ureters are already opacified from a previous study. The bladder capacity is of little significance to the radiologist, since this is to a great extent contingent upon the presence of an outflow tract obstruction, and it is the discovery of this obstruction which is of primary importance.

The patient is catheterized and a sample of urine obtained for culture and determination of sensitivity of the organisms to the different antibiotics if necessary. In older males Xylocaine ointment is injected into the urethra through a small catheter inserted just past the meatus. After a few minutes, the regular catheter is passed into the bladder.

A water-soluble opaque material (Hypaque 20 per cent²) is injected with a

² Hypaque Sodium Solution 20 per cent, brand of diatrizoate sodium, Winthrop Laboratories, New York, N.Y.

TABLE I: VOIDING CYSTOURETHROGRAMS

Total number of examinations.....	308
Normal (including 15 postoperative studies).....	171
Abnormal.....	137
Reflux.....	52
Right only.....	14
Left only.....	24
Bilateral.....	14
Posturethral and bladder neck obstructions.....	69
Male.....	8
Female.....	61
Urethral valves.....	3
Neurogenic bladder.....	4
Cystitis (radiologic manifestations).....	5
Diverticula.....	4

syringe while the bladder is monitored through the image amplifier. Any abnormality during injection, such as reflux, is recorded on a spot-film. When the bladder is distended and the patient is ready to void, the catheter is removed (Fig. 2). During voiding, spot-films (with the 4 in 1 spot-film device) are obtained in various projections. In general, the male child is filmed in the semioblique projection, and the female in both the frontal and oblique projections if possible (Figs. 3 and 4). Usually between eight and twelve films can be obtained during the act of micturition. After micturition, if some opaque medium is still retained, the patient is allowed to go to the toilet to empty the bladder under more normal circumstances. Another plain film is then taken.

The volume which the bladder can hold depends on its degree of irritability and the age of the patient. In general, it ranges from approximately 1 ounce in the newborn infant to approximately 6 ounces in the three- to five-year-old group, and, in older children, to possibly 8 to 10 ounces.

It may be difficult to initiate voiding in the older child, and various stratagems must be resorted to, such as upright positioning on the tilt table or reinserting the catheter and then, while pulling it out, exerting some suprapubic pressure. In smaller children who cannot co-operate, moderate distention of the bladder, accompanied by suprapubic pressure, will almost always initiate micturition. In our experience, this procedure may be

difficult to perform, and the frustrations in trying to initiate voiding in a stubborn three-year-old may be great. With increasing experience, however, satisfactory voiding cystourethrograms are obtained in almost 100 per cent of the cases.

MATERIAL

Three hundred and eight voiding cystourethographic studies have been performed with the above technic; in 137 examina-

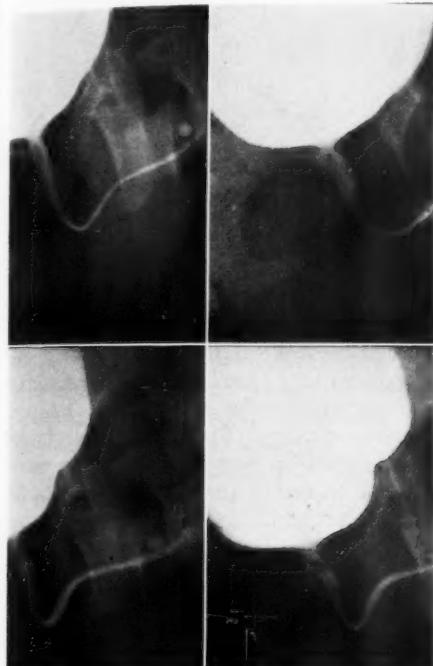


Fig. 3. S. H., two-and-a-half-year-old male. Normal voiding cystourethrogram. The verumontanum is well shown.

tions some abnormality was shown. The yield is extremely high for the number of studies performed, but it should be stressed that most of the patients were otherwise healthy children seen because of repeated urinary tract infection. Distribution of the abnormalities in this series is shown in Table I.

ABNORMALITIES DETECTED

1. *Ureteral Reflux:* It is generally conceded that urinary reflux is abnormal and

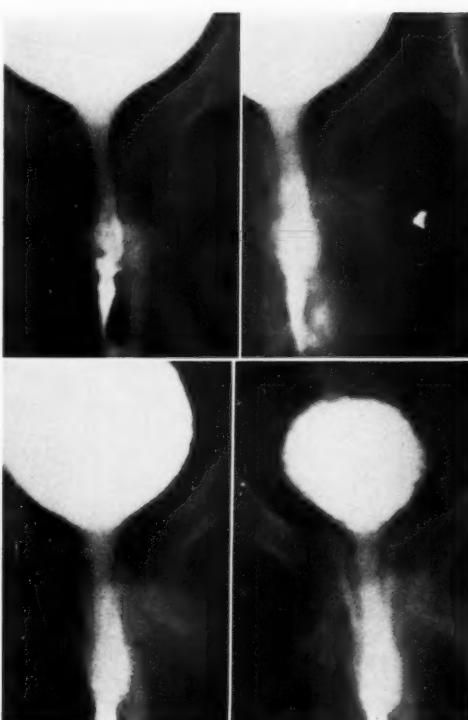


Fig. 4. S. A., four-and-a-half-year-old female. Normal voiding cystourethrogram. The vaginal reflux is very common and apparently of no clinical significance.

that, if continued, it may eventually lead to destruction of the kidney involved (6-10). This effect may be secondary to the increased pressure in the tract, but more than likely is also caused by repeated implantation infections of the upper tract from the pyogenic lower tract urine. Reflux is a threshold phenomenon and may occur at first only when a certain intravesical pressure is exceeded. A static cystogram obtained with a full bladder may therefore fail to show reflux which will be easily visualized during micturition, when the intravesical pressure is at its highest. In patients with reflux, the ureter may frequently be visualized several times during emptying, both as it fills from reflux and as it empties under its own peristaltic pressure; or the reflux may be transitory and observed and recorded once during micturition.

The causes of reflux are still obscure and

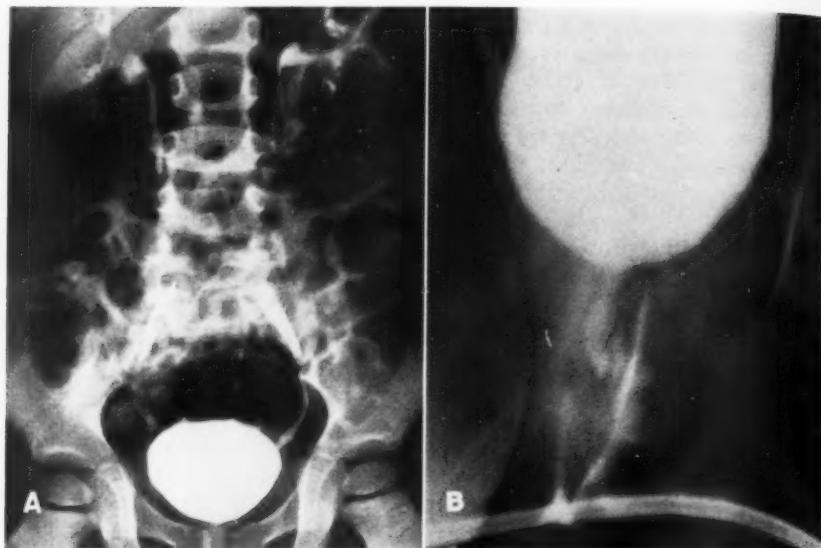


Fig. 5. L. S., female two and a half years old. A. Normal excretory urogram. B. Voiding cystourethrogram showing bilateral reflux. The bladder neck is normal. This represents a patient with cystitis and transient reflux.

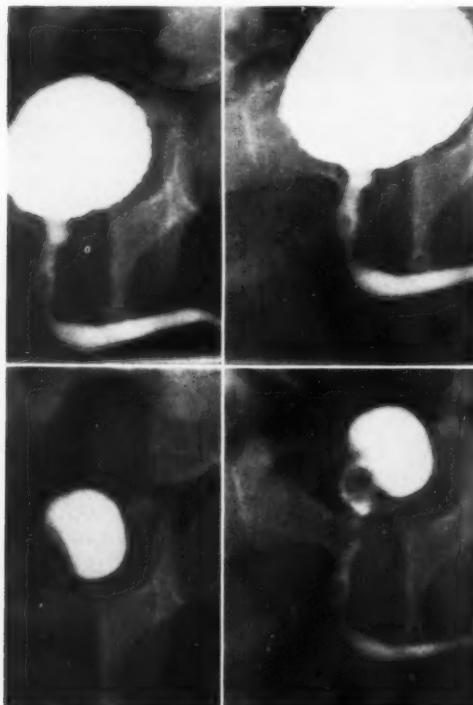


Fig. 6. P. H., five-year-old male. Voiding cystourethrogram. A large congenital bladder diverticulum is filled as the patient voids. It is not seen with the bladder completely filled.

are undoubtedly related to pressure changes in the bladder, as well as to disturbance of the normal valvular mechanism at the ureterovesical junction by perireteric change (Fig. 5). It is obvious in our clinical material that in most instances of reflux the correlation with the cystoscopic findings is poor. The cystoscopist is, more frequently than not, unable to predict which of the orifices will allow reflux, and only in an advanced case will the cystoscopic and cystographic findings correspond.

Reflux may be secondary to primary bladder inflammatory disease or to obstruction lower in the tract, as in the bladder neck or posterior urethra. In the latter case it may be compared to esophageal reflux in patients with pyloric stenosis. The reflux itself is a secondary sign of urinary tract obstruction, and it is correction of this obstruction that is a primary therapeutic aim. Detection of reflux must not of itself be the sole purpose of voiding cystourethrography.

Reflux may be reversible, though at the present time we have no exact criteria to separate those cases in which it will correct

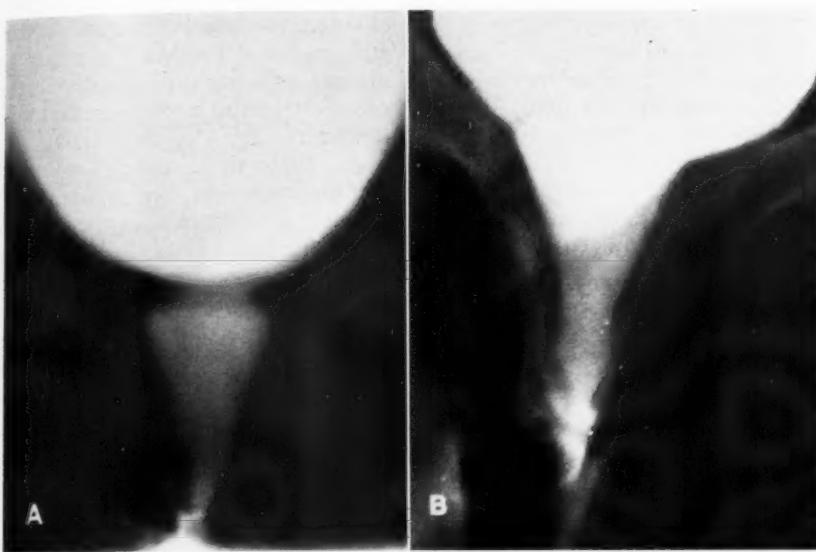


Fig. 7. M. R., female two and a half years old.

A. Voiding cystourethrogram demonstrating "collar" defect in the bladder neck.

B. Voiding cystourethrogram two months after surgical Y-V procedure. The bladder neck is now widely patent.

itself after cure of a primary cystitis or the repair of a lower urinary tract obstruction. In many patients with cystitis, reflux disappears several weeks following adequate antimicrobial therapy.

The presence or absence of peristalsis in the ureter should be observed since, if the case is advanced and peristaltic action is lost, reimplantation of the ureter will be ineffectual.

The presence of inflammatory change in the bladder is more accurately assessed by the cystoscope than by cystography. It should again be stressed that cystitis will follow any chronic obstruction of the lower urinary tract and will not be relieved until the accompanying lesion is corrected.

2. Diverticula of the Bladder: Diverticula of the bladder in infants and children are probably true diverticula and congenital in origin. Frequently they will not be shown when the bladder is fully distended, and visualization will be effected only during voiding, when the increased intravesical pressure will force the opaque material into the diverticulum (Fig. 6). These diverticula may be the site of chronic

urinary tract obstruction, and their surgical removal may be necessary. In 1 case (11) it was extremely difficult to find

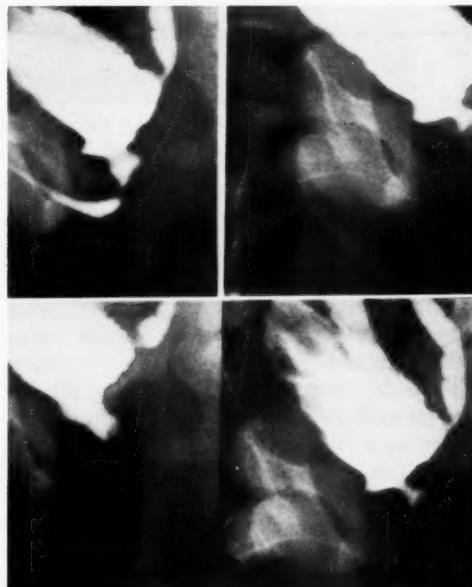


Fig. 8. K. S., male aged one year, ten months. Voiding cystourethrogram showing a marked bladder neck obstruction and bilateral ureteral reflux. The verumontanum is enlarged and obstructive.

the diverticulum at surgery, and only the fact that it was obvious on the roentgenogram resulted in its being uncovered.

3. Urethra and Bladder Neck Defect: The antegrade visualization of the urethra and bladder neck gives the truest picture of these structures in the examination of the lower urinary tract. In many young female patients with repeated bouts of urinary tract obstruction, a "collar" defect

obstructive defects of the bladder neck and posterior urethra the upper tract is normal, and in our series duplication and other congenital variants in that area were quite rare.

4. Urethral Valves: Voiding cystourethrography is the most satisfactory method of visualizing valves in the posterior urethra (5, 14). Such valves lead to obstructive uropathy at a very early



Fig. 9. I. N., twenty-day-old male.
 A. Cystogram. Urethral valves. The irritable bladder is secondary to infection. (Obstructive uropathy was evident on the excretory urogram.)
 B. Voiding cystourethrogram four months after resection of valves. There is a fairly adequate urinary stream.

is noted at the bladder neck (Fig. 7, A), the etiology of which is obscure (12, 13). A plastic Y-V procedure in this area has resulted in marked relief in most patients, and on postoperative voiding cystourethrograms the defect has disappeared and the urethra has become normal in appearance (Fig. 7, B).

Bladder-neck obstruction is more unusual in males than in females but, when it does occur, the damage to the upper tract appears to be much greater at an earlier age. In general, the excretory urogram will be abnormal in these young male patients (Fig. 8).

In the great majority of patients with

age in male infants and must be suspected and sought for before there is permanent upper urinary tract damage (Fig. 9). A poor urinary stream may be the earliest sign. Valves are not found in female patients.

5. Ectopic Ureter: In females, there may be ectopia of a ureter with the orifice in the posterior urethra, the vagina, or other external structure. The ectopic orifice is frequently missed at cystoscopy, but during voiding will often be revealed by reflux. In our experience, not all of these patients are incontinent, probably because the ectopic ureter enters just proximal to the external sphincter.

CONCLUSIONS

1. A normal excretory urogram does not rule out significant lower genitourinary tract disease in infants and children.
2. A voiding cystourethrogram should be part of the radiological work-up in all children with recurrent pyuria.
3. The diagnosis of "chronic pyelonephritis" should not be made in infants and children until lower urinary tract abnormality has been ruled out.
4. Reflux is abnormal, and may be discovered only during the act of voiding.
5. Voiding cystourethrography is the best method of detecting obstructive changes in the bladder neck and urethra, diverticula of the bladder, urethral valves, ectopic ureter, and reflux. A simple practical method of performing voiding cystourethrography with conventional x-ray equipment is described.

Childrens Hospital
226 E. Chestnut Street
Louisville 2, Ky.

REFERENCES

1. KLEEMAN, C. R., HEWITT, W. L., AND GUZE, L. B.: Pyelonephritis. *Medicine* **39**: 3-116, February 1960.

2. HODSON, C. J., AND EDWARDS, D.: Chronic Pyelonephritis and Vesico-ureteric Reflux. *Clin. Radiol.* **11**: 219-231, October 1960.
3. FULTON, H.: Delayed Cystography in Children. *Am. J. Roentgenol.* **78**: 486-491, September 1957.
4. CHRISTENSEN, E. R.: Cystography with Controlled Filling Pressure in Children. *Acta radiol.* **52**: 426-432, December 1959.
5. KJELLBERG, S. R., ERICSSON, N. O., AND RUDHE, U.: The Lower Urinary Tract in Childhood: Some Correlated Clinical and Roentgenological Observations. Chicago, Ill., Year Book Publishers, Inc., 1957.
6. IANNACCONE, G., AND PANZIRONI, P. E.: Ureteral Reflux in Normal Infants. *Acta radiol.* **44**: 451-456, December 1955.
7. JONES, B. W., AND HEADSTREAM, J. W.: Vesico-ureteral Reflux in Children. *J. Urol.* **80**: 114-115, August 1958.
8. FORSYTHE, W. I., AND WHELAN, R. F.: The Occurrence and Significance of Vesico-ureteral Reflux in Children. *Brit. J. Urol.* **30**: 189-197, June 1958.
9. McGOVERN, J. H., MARSHALL, V. F., AND PAQUIN, A. J., Jr.: Vesicoureteral Regurgitation in Children. *J. Urol.* **83**: 122-149, February 1960.
10. POLITANO, V. A.: Vesicoureteral Reflux in Children. *J.A.M.A.* **172**: 1252-1256, March 19, 1960.
11. JOHNSTON, J. H.: Vesical Diverticula Without Urinary Obstruction in Childhood. *J. Urol.* **84**: 535-538, October 1960.
12. WILLIAMS, D. I.: The Radiological Diagnosis of Lower Urinary Obstruction in the Early Years. *Brit. J. Radiol.* **27**: 473-483, September 1954.
13. THOMAS, G. K.: Marion's Disease (Contracture) of the Bladder Neck. *J. Urol.* **82**: 523-530, October 1959.
14. GRIESBACH, W. A., WATERHOUSE, R. K., AND MELLINS, H. Z.: Voiding Cystourethrography in the Diagnosis of Congenital Posterior Urethral Valves. *Am. J. Roentgenol.* **82**: 521-529, September 1959.

SUMMARIO IN INTERLINGUA

Le Vias Urinari Inferior in Infantes e Juveniles

Un simple e practic methodo es describite pro le effectuatione de cysto-urethrographia vacuatori con le uso del instrumentation radiographic conventional. In 308 studios cysto-urethographic in vacuation, un certe typo de anormalitate esseva demonstrate pro 137 casos. Iste anormalitates includeva refluxo ureteral, diverticulos del vesica, defectos del urethra e del cervice vesical, valvulas urethral, e uretere ectopic.

Un cystourethrogramma vacuatori debera esser un parte del examine radiologic in omne patientes pediatric con pyuria recurrente, proque un normal urogramma excretori non exclude le presentia de un significative morbo del vias genito-urinari inferior in iste gruppo de etate, e usque le diagnose de obstruction del vias urinari ha essite excludite per omne medio possibile, on non pote asserer que le paciente es investigate adequaremente.

Early Physiologic Nephro-urography

as a Test of Kidney Function¹

RICHARD L. SIGGERS, M.D.

SQUIRE AND SCHLEGEL concluded from a recent study that the intravenous pyelogram is not a reliable test of renal function. The failure of these inves-

fore set up to remedy this shortcoming. Prior to intravenous pyelography a preliminary film is obtained. This is of importance, since the presence of a rotated

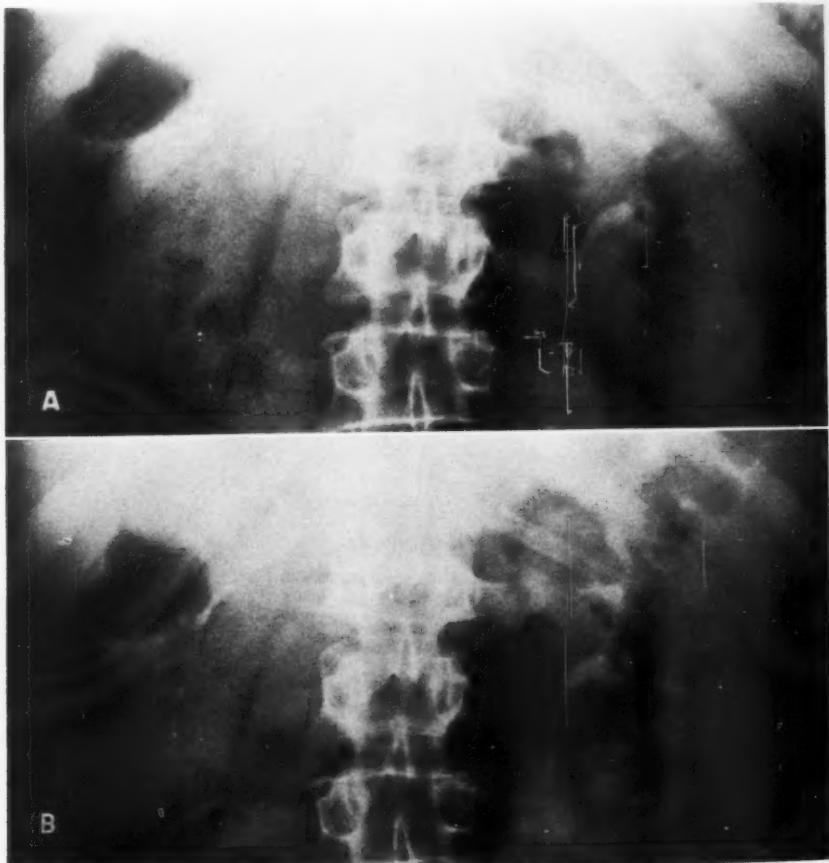


Fig. 1. Case I. A. On the two-minute film the nephrographic phase is visualized in the right kidney while the pyelographic phase is observed on the left. B. Three-minute film.

tigators to demonstrate the disparity between the function of one kidney and the other was felt by the present writer to be attributable to the circumstance that films had not been obtained at an early enough time. A program was there-

kidney may result in what may appear to be a unilateral nephrogram, or, if the kidney is rotated about its long axis, it may seem shorter than its fellow and, in the absence of a function test, may be mistakenly regarded as diseased.

¹ From the Veterans Administration Hospital, Long Beach, Calif. Accepted for publication in January 1961.

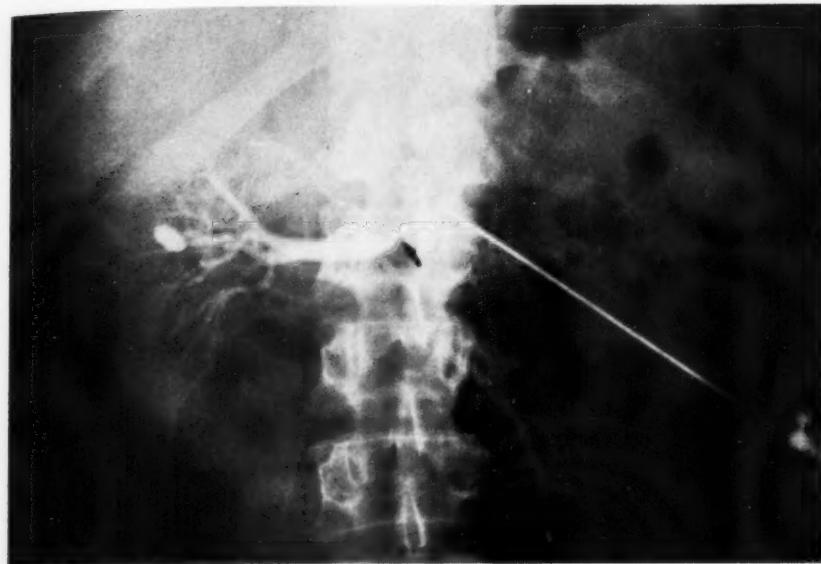


Fig. 2. Case I. Aortogram showing narrowing of right renal artery.

Thirty cubic centimeters of 50 per cent Hypaque Sodium, by weight, is injected through a 20- to 22-gauge needle in two to fifty seconds. The first film is obtained one minute after the beginning of the injection, *e.g.*, ten seconds after its termination if it takes fifty seconds, twenty seconds after its termination if it takes forty seconds, etc. A second film follows one minute after the first, and a third one minute after the second. Occasionally, it will be necessary to run the films sequentially into the four- and five-minute period. For brevity at our institution, this examination has been called "one-two-three intravenous pyelography."

The findings can be summarized as follows:

(a) When the one-minute film is exposed, a nephrogram, including a glomerulonephrogram as well as a tubular nephrogram, is obtained. This is denser than on the plain film. At two minutes (in a normal patient) the nephrographic effect is fully apparent, and in three minutes (in normal patients, without elevated blood pressure) bilateral calyceal delineation has begun. As the calyces appear, there is a gradual decrease in the

"nephrographic" effect, due to successive dilution of the contrast material by urine within the parenchymal substance of the kidney. In (essential) hypertensive patients, the calyces are often seen on the two-minute film. It would seem, therefore, that the rapidity with which the medium traverses the kidney is due to the renal arterial blood pressure.

(b) After obtaining the one-, two-, and three-minute physiologic or functional films, the routine five-, ten-, fifteen-, and twenty-minute morphologic films are exposed. Sometimes it is necessary to carry the sequential physiologic exposures to four minutes.

The important question is whether or not there is differential function between right and left kidneys in the early one-, two-, and three-minute films. The easiest end-point to delineate is the calyceal stage, *i.e.*, in which kidney the calyces are first shown.

CLINICAL REPORTS

CASE I: A 41-year old white male bartender was admitted to the VA Hospital, Long Beach, Calif., April 5, 1960, in heart failure with cardiomegaly. He gave a four-year history of hypertension, 200/135 mm. Hg.

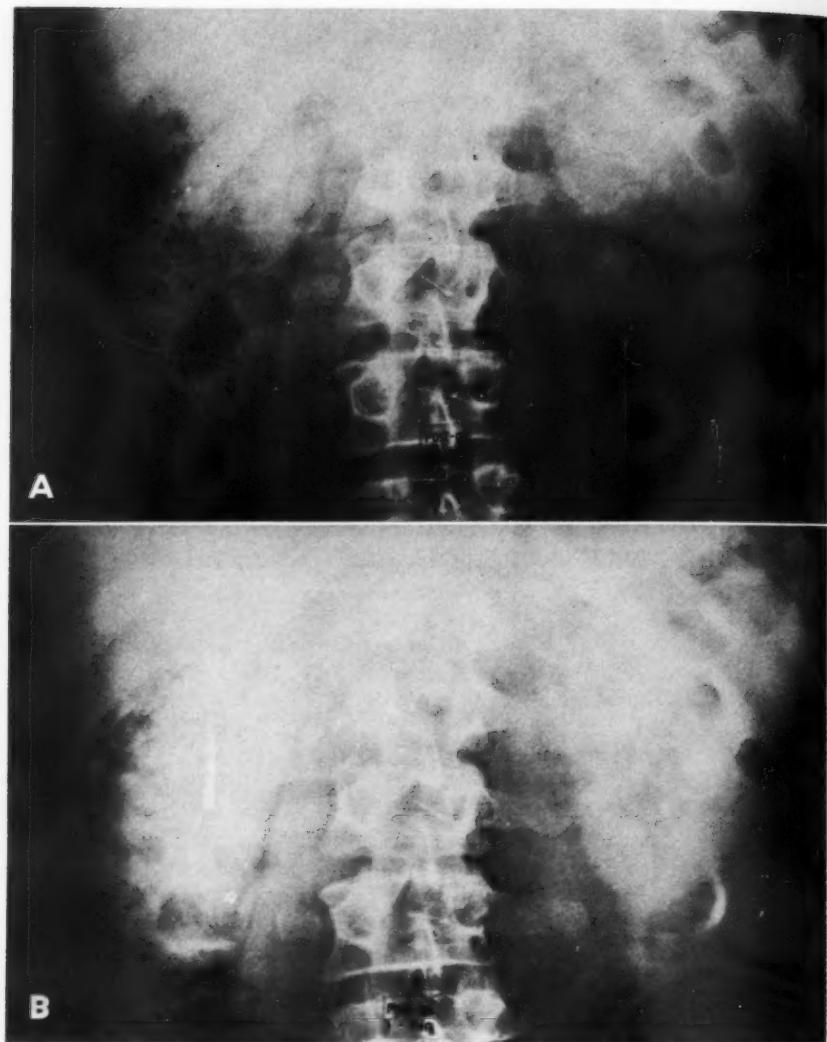


Fig. 3. Case I. Normal findings on one-two-three intravenous pyelography five months after surgery.

Physical examination revealed hypertension of 200/135 to 220/110 mm. Hg in the right and left arms in the recumbent position, and 300/155 mm. Hg in the leg. Minimal arteriolar narrowing of the retinal vessels was present, with no evidence of hemorrhages or exudates.

Laboratory studies showed blood urea nitrogen of 22 mg. per cent and a fasting blood sugar of 64. Serum potassium was 4.5 milliequivalents per liter, with 105 milliequivalents of chlorides, 137 milliequivalents per liter of sodium, and a bicarbonate level of 25 milliequivalents per liter. Twenty-four-hour urinary catecholamines were 2 gamma per cent. The regitine test was negative. A Fishberg

concentration test revealed maximum concentration to 1.017. Serum creatinine was 0.9 mg. per 100 c.c.

In the "one-two-three" pyelographic study the differential excretion of contrast material was such that at two minutes the right kidney still remained in the nephrographic phase, while the left had progressed to the pyelographic phase (Fig. 1). The patient was given digitalis, put on a low-salt diet, and treated with reserpine, Diuril, and Apresoline without any change in blood pressure. An aortogram revealed unilateral right renal artery constriction (Fig. 2). Ureteral catheterization showed differential sodium excretion, the left kidney

as the ...
77 mil...
24 mil...
Since ...
Howard...
ary to ...
schedule...
A ri...
were p...
an arte...
gist as...
after s...

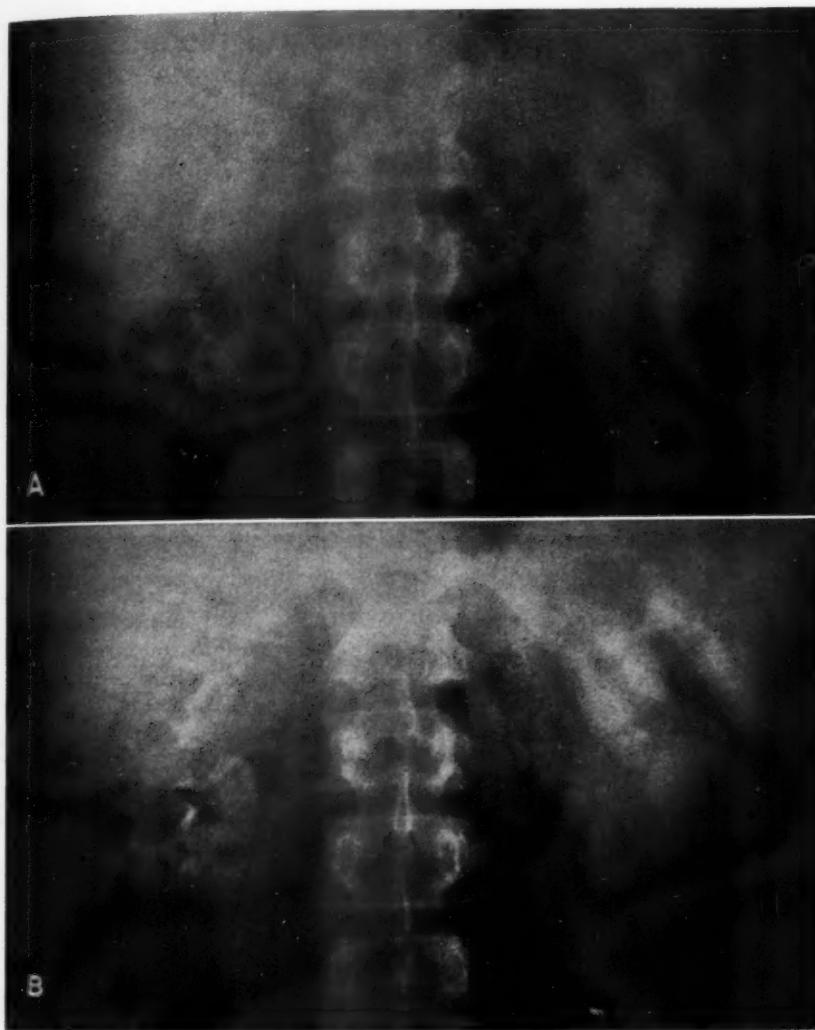


Fig. 4. Case II. Intravenous pyelograms leading to suspicion of a Goldblatt kidney. Note differential excretion on four-minute film (B).

concentration 9 mg. per study was such remained left had (Fig. 1), a low-salt and preservative. An renal artery ligation was performed. A right renal endarterectomy and appendectomy were performed. The obstruction was found to be an arteriosclerotic plaque, described by the pathologist as a "hyaline chondroid plaque." Five months after surgery, the blood pressure had gradually decreased to 140/90 mg. Hg. and repeat one-two-

three pyelography showed normal findings bilaterally (Fig. 3). At the time of submission of this paper, the patient was asymptomatic.

CASE II: A 51-year-old white male was admitted to the Long Beach VA Hospital with a history of bloody urine and hypertension since Sept. 5, 1960. In April 1960 acute anterior pain in the chest had been described as a heart attack. Blood pressure was found to be high at that time.

Physical examination revealed a fairly normal male with a blood pressure of 196/114 mm. Hg in the right arm and 196/116 in the left. No definite funduscopic changes other than slight narrowing

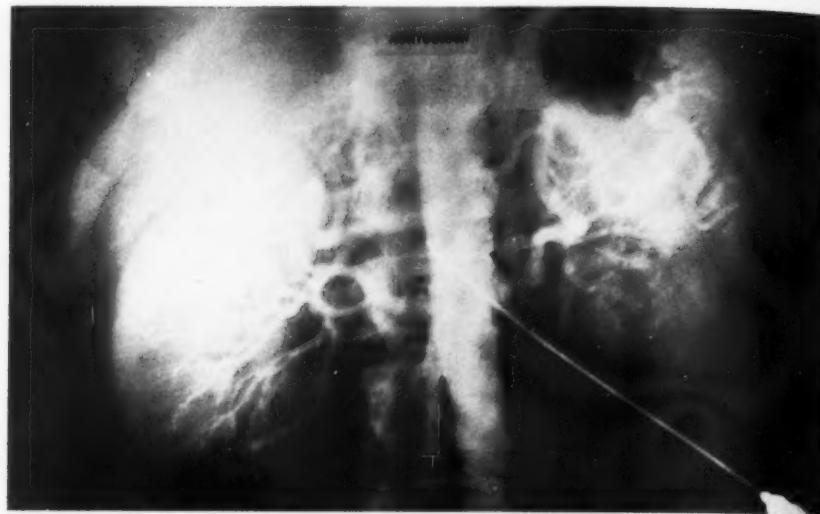


Fig. 5. Case II. Aortogram showing block just distal to bifurcation of left renal artery.

of the arterioles was found. The patient mentioned left upper quadrant pain on palpation.

Electrocardiography showed ventricular hypertrophy on the left. Urinalysis revealed 70 to 80 red blood cells per low-power field, with albumin 1+. Concentration was to 1.015. Sodium was reported at 138 milliequivalents per liter, potassium at 5.1 milliequivalents per liter, chlorides at 100 milliequivalents per liter, calcium at 11.8 milliequivalents per liter, and phosphorus at 3.8 mg. per 100 c.c. The creatinine clearance was 114 c.c. per minute. The catecholamines were 7 micrograms per 100 c.c. The one-two-three films were extended to the four-minute level and showed differential function between the right and left sides. A Goldblatt left kidney was suspected (Fig. 4).

Aortography showed a block just distal to the bifurcation of the left renal artery, measuring 4 mm. in extent (Fig. 5).

A Howard test demonstrated differential function between the two kidneys, and operation was scheduled. A generalized arteriosclerosis of the aorta was seen at surgery. The left common iliac artery was almost completely occluded, and a block due to an arteriosclerotic plaque was present 1 cm. from the origin of the left renal artery. A left renal endarterectomy under hypothermia (32°C.) was performed. In the postoperative period, there was a fall in blood pressure to 156/90 mm. Hg.

CONCLUSIONS

Intravenous pyelography, if performed soon enough after injection of contrast material, delineates arterial insufficiency of

the kidney. Films should be obtained sequentially at one-minute intervals beginning at one minute from the commencement of injection and continued until bilateral calyceal delineation is depicted. Arterial insufficiency will be defined by the difference between the rapidity of appearance of the calyceal phase in the two kidneys. The Goldblatt kidney, therefore, can be defined by pyelography.

Long Beach Veterans Hospital
Long Beach, Calif.

REFERENCES

- SQUIRE, L. F., AND SCHLEGEL, J. U.: Pyelography in Renal Disease with Hypertension. Correlation Between Pyelographic Findings and Differential Renal Function Studies. *Radiology* 73: 849-864, December 1959.
- DANIEL, P. M., PRICHARD, M. M. L., AND WARD-McQUAID, J. N.: Renal Circulation in Experimental Hypertension; Angiographic and Morphologic Studies in the Rabbit. *Brit. J. Surg.* 42: 81-95, July 1954.
- LEVY, S. E., MASON, M. F., HARRISON, T. R., AND BLALOCK, A.: Effects of Ureteral Occlusion on Blood Flow and Oxygen Consumption of Kidneys of Anesthetized Dogs. *Surgery* 1: 238-242, February 1937.
- WEENS, H. S., OLICK, H. M., JAMES, D. F., AND WARREN, J. V.: Intravenous Aortography and Nephrography. *Am. J. Med.* 5: 620, October 1948.
- PAGE, I. H., DUSTAN, H. P., AND POUTASSE, E. F.: Mechanisms, Diagnosis and Treatment of Hypertension of Renal Vascular Origin. *Ann. Int. Med.* 51: 196-211, August 1959.

GOLDBLATT, H.: Experimental Hypertension Induced by Renal Ischemia: Harvey Lecture. *Bull. New York Acad. Med.* **14**: 523-553, September 1938.
 GOLDBLATT, H., LYNCH, J., HANZAL, R. F., AND SOMMERVILLE, W. W.: Studies on Experimental Hypertension; Production of Persistent Elevation of

Systolic Blood Pressure by Means of Renal Ischemia. *J. Exper. Med.* **59**: 347-379, March 1934.

BOOKSTEIN, J. J., AND ABRAMS, H. L.: Surgically Correctable Renal Hypertension; A Review and Presentation of Four Cases. *Radiology* **75**: 207-214, August 1960.

SUMMARIO IN INTERLINGUA

Precoce Nephrourethrogramma Physiologic Como Test del Function Renal

Pyelographia intravenose, si effectuate satis precocemente post le injection del substantia de contrasto, servi como test del function renal. In pelliculas obtenite a intervallos de un minuta a partir de un minuta post le comenciamento del injec-

tion, insufficiencia arterial del renes es definite per le differentia in le rapiditate del apparition del phase calycee inter le duo lateres. Le ren de Goldblatt, per consequente, pote esser definite per pyelographia. Duo casos es presentate.



Calculation of the Dose Distribution in Circumaxial Rotation Therapy with 280-kvp Radiation¹

H. F. BATHO, Ph.D., and M. E. J. YOUNG, M.Sc.

TO CALCULATE the distribution of dose produced in circumaxial rotation therapy, it is customary to represent the moving field by a number of stationary fields. The quantity which is normally measured is the exposure dose rate in air at the centre of rotation. From this, the contribution of each stationary field to the exposure dose at the centre of rotation with the patient in the beam can be determined easily and accurately by means of Johns' tumour-air ratios (1, 2).

The dose at points other than the centre of rotation can, in theory, be determined with fair accuracy by straightforward application of conventional isodose charts to each of the fixed fields used to represent the moving field. This requires, in general, a different isodose chart for each stationary field since the focus-skin distance and the area of the field on the skin differ for each field. Unless approximations are made, the procedure is impractical for routine work because of the large number of isodose charts required. Some suitable approximations have been investigated by Quimby and her co-workers (3, 4). Wheatley (5) avoids the use of isodose charts by estimating the primary and secondary dose contributions at each required point from empirical central axis depth-dose tables. In practice the calculations by Wheatley's method are laborious since they require that, for each point in each fixed field, a correction factor be obtained from the tables for each variable involved.

For cobalt-60 radiation, Braestrup (6) and Jones (7) have found that it is satisfactory to use a single isodose chart for each field size at the centre of rotation, irrespective of the changing source-skin

distance and changing field size on the skin. This is possible because, for high energy radiation, the ratio of the doses at two given points is almost independent of the thickness of overlying tissue.

In Braestrup's method, the exposure dose at the centre of rotation is determined accurately by means of tumour-air ratios. The dose at other points relative to the dose at the centre of rotation is read for each fixed field from an isodose chart plotted with the dose at the centre of rotation (rather than the maximum dose in the field) as 100 per cent. In determining the dose at any point due to one stationary field, the chart is placed so the 100 per cent point is at the centre of rotation and the percentage dose at the point as read from the chart is multiplied by the tumour-air ratio for the field; the total dose at the point for one complete revolution is found by taking the sum of doses from each of the fixed fields.

The present investigation was designed to determine the minimal modifications in Braestrup's method necessary to make it applicable to rotation techniques with conventional deep therapy x-rays. The procedure was to determine the experimental dose distribution in a water phantom due to circumaxial rotation with given irradiation conditions and to compare this distribution with the distributions calculated on different assumptions or approximations. It was not found satisfactory to follow Braestrup's procedure of using a single isodose chart for each field size, regardless of the focus-skin distance, but it has been possible to obtain acceptable agreement between calculated and experimental distributions with only a limited number of isodose charts.

¹ From the British Columbia Cancer Institute, Vancouver, B. C., Canada. Accepted for publication in February 1961.

This project was supported in part by a grant from the National Cancer Institute of Canada and in part by the Order of the Eastern Star.

PROCEDURE

All experimental irradiations in this investigation were made with a Picker Vanguard x-ray unit operated at 280 kvp with added filter of 0.80 mm. Sn + 0.25 mm. Cu + 1.0 mm. Al, yielding a half-value layer of 3 mm. Cu. The distance from the target to the axis of rotation with this unit is 65 cm.

All dose measurements were made with a Baldwin-Farmer Substandard Dosemeter. This necessitated successive rather than simultaneous measurements at different points in a phantom; this procedure was satisfactory since the output of the Vanguard is constant within 1 or 2 per cent. (Simultaneous measurements with Baldwin BD2 ionization chambers were used in the early stages of the work but these were found less reproducible than successive measurements with the Substandard Dosemeter.)

Three Plexiglas tanks filled with water were used as phantoms in the investigation. These had dimensions as follows:

- (a) Small. A cylinder of elliptic cross section, major axis 20 cm. and minor axis 15 cm.
- (b) Large. A cylinder of elliptic cross section, major axis 40 cm. and minor axis 35 cm.
- (c) Medium. A model of a chest, the mean section having a lateral dimension of 33 cm. and an antero-posterior dimension of 24 cm.

The field sizes in the investigation were 4×6 , 6×6 , 6×18 , and 8×18 sq. cm., all as measured at the centre of rotation.

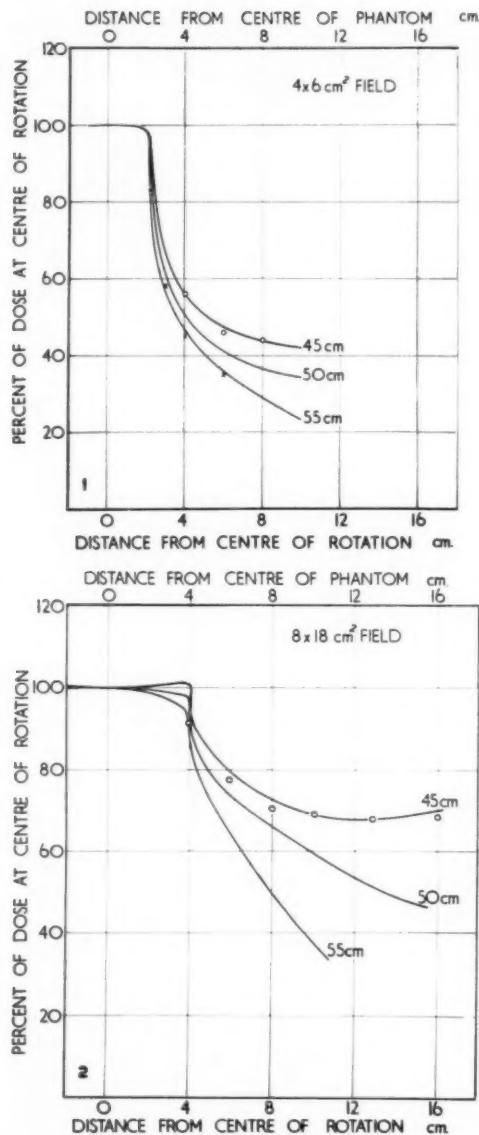
For purposes of calculation, isodose charts were prepared for each of the above field sizes for five different focus-skin distances: 40, 45, 50, 55, and 60 cm. The depth-dose data from which these charts were drawn were calculated from central axis depth-dose data for the appropriate F.S.D. by the equivalent circle method of Jones (8) and Day (9) with equivalent radii as determined by Batho, Theimer, and Theimer (10). The computations were made with an ALWAC IIIE electronic computer (11). The central axis

depth-dose data for 50 cm. and 60 cm. F.S.D. were taken from the British Journal of Radiology, Supplement V, and the central axis data for 40, 45, and 55 cm. F.S.D. were derived from these data by the method described by Johns (2). The isodose charts were plotted with the dose at the centre of rotation as 100 per cent (*i.e.*, since the source-axis distance was 65 cm., the depth doses computed for 60 cm. F.S.D. were divided by the central axis dose at 5 cm. depth, the depth doses for 55 cm. F.S.D. were divided by the central axis dose at 10 cm. depth, etc.). The charts showed the scatter beyond the geometrical edges of the beam to at least 20 per cent and usually to 10 per cent of the value at the centre of rotation.

In calculating dose distributions the dose at any point was determined as in Braestrup's method. In general, the rotating field was represented by 24 stationary fields. However, for points outside the continuously irradiated volume, for those stationary fields where the geometrical edge of the rotating field would move across the point considered and the dose within and without the edge differed appreciably, a weighted mean of the dose within and without the edge was used, the values being weighted in proportion to the time the point was inside or outside respectively. With this precaution, a smooth curve could be drawn through the calculated points such that all points lay within ± 3 per cent of the curve. The departure of the points from the curve can be explained adequately by the possible errors in the isodose curves used, the inherent error in replacing the rotating field by a finite number of stationary fields and errors of interpolation. The smooth curve only is shown in the graphs which follow.

RESULTS

In all cases where the dose at the centre of rotation was measured directly, the difference between the measured value and the value calculated by means of tumour-air ratios was less than the error of measurement.



Figs. 1 and 2. Dose distribution in elliptical water phantoms (phantoms *a* and *b* of text) with centre of rotation at centre of phantom. Distribution shown is from the centre outward along the major axis of the ellipse in each case.

Solid curves. Each curve calculated with the isodose chart for the F.S.D. shown on the curve. (Calculated curves identical for small and large phantoms.)

Crosses. Experimental points with small phantom. (Mean F.S.D. = 56.4 cm.)

Circles. Experimental points with large phantom. (Mean F.S.D. = 46.4 cm.)

Figures 1 to 4 are typical of the results obtained when measured and calculated distributions in the various phantoms were compared for the different field sizes given above.

In Figures 1 and 2 the centre of rotation was at the centre of the phantom and the distribution shown is from the centre outward along the major axis of the ellipse. The calculated distributions are shown as solid lines and the experimental measurements as points. For each solid line, a single isodose chart was used (F.S.D. shown on the diagram). It is to be noted that with a given isodose chart the same calculated distribution is obtained for either the small or large ellipse (phantoms *a* and *b* above), *i.e.*, each solid line can be taken as the calculated distribution for either phantom. The identity of the two calculated distributions arises from the fact that the two elliptical phantoms are of such shape that the larger can be produced by surrounding the smaller by an annulus of constant width.

Within the region which is continuously irradiated during the rotation, the differences in the distributions calculated with different focus-skin distances are usually negligible but, outside this region, the larger the field size the more marked the differences. For the small phantom, with the centre of rotation at the centre of the phantom the range of focus-skin distances is 55.0 to 57.5 cm. with a mean F.S.D. of 56.4 cm. For the large ellipse, the range of F.S.D.'s is 45.0 to 47.5 cm. with a mean value of 46.4 cm. Within the limits of accuracy of measurement and calculation, the experimental points are in agreement with the values to be expected from the mean F.S.D. of each phantom. Similar agreement was obtained when distributions calculated and measured in the medium phantom were compared.

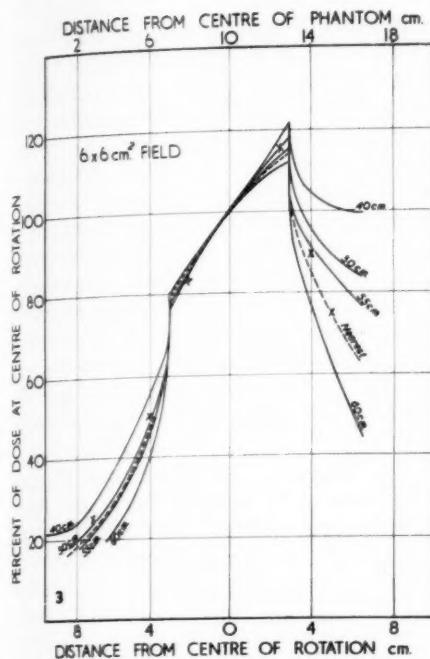
With the centre of rotation at the centre of the phantom, the dose distribution along the minor axis of the phantom is essentially similar to that along the major axis but

the results
calculated
oms were
zes given

of rotation
and the
entre out-
e ellipse.
shown as
measured
line, a
D. shown
that
ame cal-
or either
s *a* and *b*
be taken
or either
two cal-
the fact
e of such
duced by
nulus of

nuously
e differ-
ed with
usually
on, the
ked the
m, with
e of the
stances
F.S.D.
ose, the
, with a
in the
ent and
s are in
expected
phantom.
when
ured in
red.

the centre
n along
entially
xis but



Figs. 3 and 4. Dose distribution in water phantoms with centre of rotation displaced 10 cm. laterally from centre of phantom. The distribution shown is along the major axis.

Fig. 3. Distribution in medium phantom; 6×6 sq. cm. field.

Fig. 4. Distribution in large phantom; 8×18 sq. cm. field.

Solid curves. Each curve calculated using the isodose chart for the F.S.D. shown on the curve.

Dashed curves. Calculated with "nearest" F.S.D. for each stationary field.

Crosses. Experimental points with medium phantom.

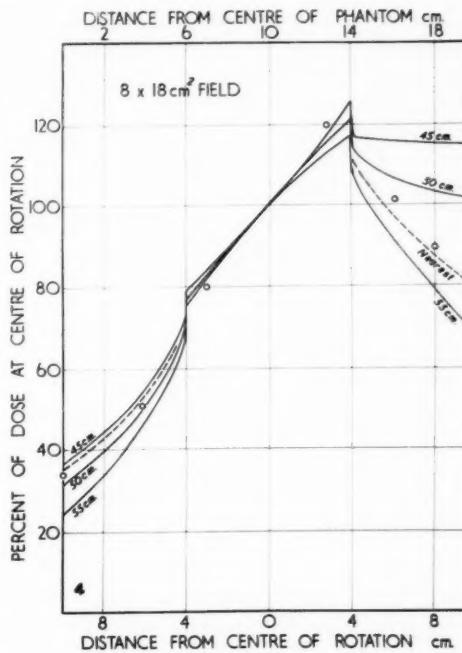
Circles. Experimental points with large phantom.

the relative doses outside the continuously irradiated region are higher.

A more critical test of any method of calculating distribution is obtained when the centre of rotation is displaced from the centre of the phantom since the range of focus-skin distances is increased greatly. Figures 3 and 4 are typical of the results obtained when the centre of rotation is displaced from the centre of the phantom. In these figures calculated and experimental distributions along the major axis of the phantom are compared for cases in which the centre of rotation is displaced 10 cm. laterally from the centre of the phantom. The field size and size of phantom are shown on each figure. Each solid curve was calculated with a single isodose chart (F.S.D. shown on the curve). The dashed curve in each figure was

calculated with several isodose charts, *i.e.*, the percentage depth doses due to each fixed field were read from the isodose chart for the F.S.D. most nearly correct for that field. This procedure has been indicated on the diagram by labeling the curve "nearest F.S.D."

With the centre of rotation displaced 10 cm. laterally from the centre of the phantom, the range of F.S.D.'s for the "medium" phantom is 38.5 to 58.5 cm. and the mean F.S.D. is 51.9 cm. For the large phantom, the range is 35 to 55 cm. and the mean 47.6 cm. The mean F.S.D. of the "near" side of the phantom (*i.e.*, the mean of the 12 radii on the side toward which the centre of rotation is displaced) is 57.2 cm. for the medium phantom and 53.3 cm. for the large phantom. It will be seen that the best agreement with the



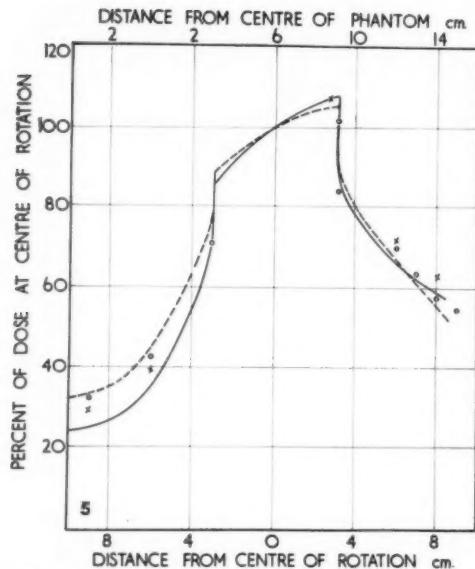


Fig. 5. Comparison of lateral distributions for two fields of the same width but different lengths. Centre of rotation 6 cm. lateral to centre of phantom. Medium phantom.

Solid curve. Calculated for 6×6 sq. cm. field.
 Crosses. Experimental points for 6×6 sq. cm. field.
 Dashed curve. Calculated for 6×18 sq. cm. field.
 Circles. Experimental points for 6×18 sq. cm. field.

experimental points was obtained by using the "nearest F.S.D." for each field but a fair approximation can be obtained by using one chart for all fields if the F.S.D. chosen is the mean F.S.D. for the "near side" of the phantom rather than the mean for all fields.

Figure 5 is typical of a set of figures prepared to show the effect upon the dose distribution of changing the length but not the width of the field. The fields compared are 6×6 sq. cm. and 6×18 sq. cm. The calculated values were derived by using the most nearly correct F.S.D. for each field.

DISCUSSION OF RESULTS

For 280-kvp radiation, if interest is confined to the distribution of dose within the continuously irradiated volume, variations of F.S.D. may be ignored without serious error and a single isodose chart for each field size is sufficient. If an isodose

chart plotted for an F.S.D. of $(R-15)$ cm., where R is the radius of rotation, is used for all cases the error within the continuously irradiated region is unlikely to exceed 5 per cent.

For estimates of dose at points outside the continuously irradiated volume, changes in F.S.D. cannot be ignored without introducing significant errors. It appears sufficient, however, to prepare isodose charts for 5 cm. intervals of F.S.D. and, so long as the centre of rotation coincides with the centre of the body, it is permissible to use a single isodose chart for all fields, choosing the chart for the F.S.D. most nearly equal to the mean F.S.D. of the section. This procedure is more likely to lead to significant errors for large fields than it is for small fields since for large fields, a 5 cm. change in F.S.D. causes a greater change in the calculated distribution. The error, however, will seldom exceed 5 per cent of the dose at the centre of rotation.

With eccentric tumours, the assumption of constant F.S.D. for all fields (*i.e.*, the use of a single isodose chart for all fields) can result in appreciable distortion of the distribution (*e.g.*, see Fig. 4). This distortion is substantially avoided and the errors are reduced considerably by using for each field the isodose chart for the F.S.D. most nearly equal to the true F.S.D. for the field. If, with eccentric tumours, a single isodose chart is to be employed for all fields, the chart chosen should be that for the F.S.D. most nearly equal to the mean F.S.D. for the "near" side of the section. There is, however, little saving in time in using a single isodose chart and, as pointed out above, some loss in accuracy.

With eccentric tumours in large body sections, fields with focus-skin distances as small as $(R-25)$ cm. may be encountered in practice (where R is the radius of revolution). Such fields, however, seldom contribute appreciably to the total tumour dose. It appears satisfactory to prepare isodose charts only for F.S.D.'s of $(R-5)$, $(R-10)$, $(R-15)$, and $(R-20)$ cm., using the latter chart for all fields for which the

true F.S.D. is greater than ($R-17.5$) cm. From comparisons such as that shown in Figure 5, it is found that a change in the elongation factor of a field from 1:1 to 3:1, the width of the field remaining constant, changes the dose outside the continuously irradiated volume by 5 to 10 per cent, *i.e.*, produces a change comparable with that made by a 5 cm. change in F.S.D. It is consistent, therefore, with the approximations proposed above to use only two isodose charts for all fields of a given width, one for square or nearly square fields and one for more elongated fields. Isodose charts for 4×4 , 4×12 , 5×5 , 5×15 , 6×6 , 6×18 , 7×7 , 7×18 , 8×8 , and 8×20 sq. cm. should be sufficient for all fields of width 4 to 8 cm. (Fields of greater width than 8 cm. are unlikely to be used with 280-kvp radiation since with wider fields there is little localization of dose).

Thus, 40 isodose charts (10 different field sizes for each of four different F.S.D.) are sufficient to determine dose distributions with acceptable accuracy for all field widths from 4 to 8 cm. in all body sections likely to be encountered in practice in circumaxial rotation with conventional deep therapy x-ray equipment. This is scarcely greater than the number of isodose charts required for stationary therapy with similar equipment. The preparation of the charts is facilitated greatly by the use of an electronic computer to compute the necessary depth-dose data.

The limitation in the number of isodose curves used to determine dose distributions as here proposed results in errors in relative doses only. These errors are greatest at points remote from the centre of rotation and approach zero as the centre of rotation is approached.² The absolute dose at the centre of rotation may be determined with

² The distribution of the errors is similar to that in Farr's method of dosage calculation (12) but no detailed account of this latter method has been seen by the authors.

considerable accuracy by means of tumour-air ratios.

Quimby (3, 4) has suggested that isodose charts for one or, at most, two F.S.D.'s are sufficient for each field size. The requirement of isodose charts for four F.S.D.'s in the present work appears to be due to greater emphasis on the region outside the continuously irradiated volume.

No test has been made of the accuracy which can be obtained when the approximations here proposed are applied to arc therapy but it is to be expected that the agreement between calculated and experimental distributions would be similar to that obtained with eccentric tumours.

British Columbia Cancer Institute
Vancouver 9, B. C., Canada

REFERENCES

1. JOHNS, H. E., WHITMORE, G. F., WATSON, T. A., AND UMBERG, F. H.: A System of Dosimetry for Rotation Therapy with Typical Rotation Distributions. *J. Canad. A. Radiologists* **4**: 1-14, March 1953.
2. JOHNS, H. E., BRUCE, W. R., AND REID, W. B.: The Dependence of Depth Dose on Focal Skin Distance. *Brit. J. Radiol.* **31**: 254-260, May 1958.
3. KLIGERMAN, M. M., ROSEN, E. G., AND QUIMBY, E. H.: Rotation Therapy Techniques Applicable to Standard Deep-X-Ray Machines. *Radiology* **62**: 183-193, February 1954.
4. CASTRO, V., SOIFER, C., AND QUIMBY, E. H.: Calculation of Dosage in Vertical Rotation Therapy Using Standard Isodose Charts. *Am. J. Roentgenol.* **73**: 815-826, May 1955.
5. WHEATLEY, B. M.: A Method of Dose Calculation with Applications to Moving-Field Therapy. *Brit. J. Radiol.* **28**: 566-573, October 1955.
6. BRAESTRUP, C. B., AND MOONEY, R. T.: Physical Aspects of Rotating Telecobalt Equipment. *Radiology* **64**: 17-27, January 1955.
7. JONES, D. E. A., GREGORY, C., AND BIRCHALL, I.: Dosage Distribution in Rotational Cobalt 60 Therapy. *Brit. J. Radiol.* **29**: 196-201, April 1956.
8. JONES, D. E. A.: A Note on Back-Scatter and Depth Doses for Elongated Rectangular X-Ray Fields. *Brit. J. Radiol.* **22**: 342-345, June 1949.
9. DAY, M. J.: A Note on the Calculation of Dose in X-Ray Fields. *Brit. J. Radiol.* **23**: 368-369, June 1950.
10. BATHO, H. F., THEIMER, O., AND THEIMER, R.: A Consideration of the Equivalent Circle Method of Calculating Depth Doses for Rectangular X-Ray Fields. *J. Canad. A. Radiologists* **7**: 51-53, December 1956.
11. YOUNG, M. E. J., AND BATHO, H. F.: The Use of Electronic Computers to Calculate Data for Isodose Curves. *Brit. J. Radiol.* **32**: 629, September 1959.
12. FARR, R. F.: Rotation Therapy: A Method of Dosage Calculation. *Hosp. Physicists' A. Bull.* **5**: (No. 1) 6, March 1958.

(*Pro le sumario in interlingua, vider le pagina sequente*)

SUMMARIO IN INTERLINGUA

Calculation del Distribution de Dosage in Therapia a Rotation Circumaxial con Radiation de 280 kvp

Es presentate un metodo pro calcular le distribution de dose in therapia a rotation circumaxial con radiation de 280 kvp, a base de un modification minimal del metodo de Braestrup. Le dimensiones de campo esseva 4×6 , 6×6 , 6×18 , e 8×18 cm², omnes mesurate al centro del rotation. Pro le objectivos del calculation, diagrammas de isodosage esseva preparate pro cata un del dimensiones de campo pro cinque differente distantias foco-pelle, i.e. pro 40, 45, 50, 55 e 60 cm.

In omne le casos in que le dose al centro del rotation esseva mesurate directemente, le differentia inter le mesurate valor e le valor calculate per medio de proportiones tumor-aere esseva minus que le error del mesuration. Intra le region que es irradiate continuemente durante le rotation le differentias in le distributiones calculate con differente distantias foco-pelle es usualmente negligibile. Tamen, foras de ille region, le regula vale que quanto plus grande es le dimensiones del campo, tanto plus marcate es le differentias. Con le centro del rotation al centro del phantom, le distribution del dose al longo del axe minor del phantom es essentialmente identic con illo al longo del axe major, sed le doses relative foras del continuemente irradiate region es plus alte. Con le centro de rotation displaciante per 10 cm lateralmente ab le centro del phantom, le melhor accordo con le punctos experimental esseva obtenite per le uso del plus proxime distantia foco-pelle pro omne campo particular.

Pro un radiation de 280 kvp—si le interesse es restringite al distribution del

dose intra le continuemente irradiate volumine—variation del distantia foco-pelle pote esser negligite sin serie error, e un sol diagramma de isodosage pro omne dimension de campo es sufficiente. Si un diagramma de isodosage preparate pro un distantia foco-pelle de R-15 cm (con R = radius de rotation) es usate pro omne casos, le error intra le continuemente irradiate region va probabilissimemente non exceder 5 pro cento. In le caso de un tumor eccentric, le supposition de un constante distantia foco-pelle pro omne campos pote resultar in un appreciabile distortion del distribution. Iste distortion es substantialmente reducite e le resultante errores es considerabilmente attenuate si on usa pro omne campo le diagramma de isodosage pro le distantia foco-pelle que es le plus proximemente equal al ver distantia foco-pelle pro le campo in question.

Le requerimento de diagrammas de isodosage pro quatro distantias foco-pelle in le presente studio pare resultar del plus grande attention prestate al region foras del continuemente irradiate volumine. Le limitation in le numero del curvas de isodosage usate pro determinar le distributiones de dose (secundo le hic-presentate proponimento) resulta in errores in solmente le doses relative. Iste errores es le plus grande al punctos distante ab le centro de rotation e approcha zero con le approche al centro del rotation. Le zero absolute al centro de rotation pote esser determinate con grados considerable de exactitude per medio del proportiones tumor-aere.

The Treatment of Advanced Carcinoma of the Bladder

A Report on 89 Patients Treated with Either Two-Million-Volt or Cobalt-60 Therapy or with a Combination of This Type of Irradiation and Surgery¹

RUTH GUTTMANN, M.D.,² and ANTONIO BAUZA, M.D.³

THE TREATMENT of advanced carcinoma of the bladder has proved unsatisfactory, whatever the method, whether radiotherapy or surgery. The advent of "super-voltage therapy" was therefore greeted with great hopes and expectations as a possible means of improving results where other procedures were known to have failed. Various preliminary reports have appeared in the course of recent years on this subject, some describing favorable results, others less optimistic, but no large groups have been followed for five years or longer.

It is hoped that this additional report on a total of 89 patients who were treated at the Francis Delafield Hospital, New York, between January 1951 and January 1960 may add some information which will be helpful in the difficult problem presented by recurrent or primary advanced carcinoma of the bladder. Two groups of patients will be evaluated: one, a group of 79 who received either two-million volt or cobalt-60 therapy, and a second, smaller group of 10, who were treated with a combination of radiation, either two-million-volt or cobalt-60 irradiation, and a surgical procedure.

The group of 79 patients who were given either two-million-volt or cobalt-60 therapy will be considered first. Forty-two of these had already received various types of treatment when we saw them for the first time. Known distant metastases were present in 14 before the beginning of therapy. It is obviously difficult, if not impossible, to classify such a group according to the staging suggested by Whitmore and Marshall (Table I), but it can be said that none of our cases were of Stage O or Stage A.

TABLE I: TUMOR STAGING SUGGESTED BY WHITMORE AND MARSHALL (22)

Stage A-B	Stage O	Tumor limited to mucosa.
	Stage A	Tumor not beyond submucosa.
	Stage B ₁	Tumor not more than halfway through muscle.
	Stage B ₂	Tumor more than halfway through muscle but not beyond muscle.
Stage C	Stage C	Tumor beyond muscle but not metastatic.
	Stage D ₁	Tumor metastatic to points within the confines of the pelvis.
Stage D Inoperable	Stage D ₂	Tumor metastatic to points outside the confines of the pelvis.

Nine were classified as questionable Stage B₁, but were more likely Stage B₂ when we first saw them. Fourteen were classified as Stage D₂ and the remaining 66 patients had disease of either Stage B₂ or Stages C or D₁. Many of the tumors treated with other methods, originally not deeply invasive, had become advanced and deeply invasive at the time the patient was first seen in our hospital.

Table II shows the microscopic classification of the disease in this patient group:

TABLE II: MICROSCOPIC CLASSIFICATION OF DISEASE IN 79 PATIENTS

Type and Grade	No. of Patients
Transitional-cell carcinoma	49
Totally undifferentiated carcinoma	12
Squamous-cell carcinoma	9
Adenocarcinoma	2
Carcinoma of the bladder	7
	79

Sixty of the patients were male and 19 female. Our youngest patient was thirty-seven and the oldest eighty-eight years of age at the beginning of therapy.

The treatment approach in this group has depended on various factors; first, of

¹ From the Department of Radiotherapy (R. G., Director), Francis Delafield Hospital, New York, N. Y. Accepted for publication in February 1961.

² Associate Professor of Radiology, Columbia University, New York, N. Y.

³ Now in Ponce, Puerto Rico.

course, on the extent of the disease and on the previous treatment. Advanced recurrent carcinoma and cases with known metastases were treated with limited intent only, in the hope of controlling the local disease for some time, and of keeping the patient comfortable as long as possible. The tumor dosage used in this group was 3,000 r, delivered in three weeks through large opposing pelvic fields, though there were, of course, individual variations. Nor was the dosage in the other patients completely uniform. When this project was started in 1951, only a two-million-volt unit was available and treatment was administered through stationary opposing 15×15 -cm. fields. A total tumor dose of 4,000 to 6,000 r was delivered in four to six weeks, depending on the tolerance of the patient. When a rotating cobalt-60 unit was installed in 1953, treatment was given with either full rotation or an anterior scanning approach through 6×15 -cm. fields. The anterior scan was used in tumors where no penetration of the disease toward prostate or rectum had as yet occurred and it was felt that the rectum could therefore be spared. Full rotation, however, was applied when the disease had extended posteriorly and a full dosage to these areas seemed necessary.

The daily tumor dose delivered in most cases was 200 r and only in the presence of severe infection was this decreased to 100 r. The immediate tolerance to this amount of radiation was good. We found it hard to evaluate an increase or decrease of frequency of burning pain under treatment, but we were certain about the definite improvement of hematuria in many cases under therapy. Rectal irritation, spasm, or some diarrhea occurred in a small percentage of patients and subsided after a short time. In one patient treated with 6,000 r in forty-five days, autopsy showed considerable fibrosis of the rectal sigmoid area, with a fistula thought to be "most likely due to the previous radiation," but altogether it can be stated that local tolerance as well as general tolerance to a dosage of this magnitude has been good.

In the attempt to evaluate the results of therapy in this group of patients with advanced carcinoma of the bladder, we broke them down into the two groups into which they had been originally divided, namely, those treated with limited intent and those treated radically. In the first group, treated with limited intent because of previous aggressive therapy or known distant metastases, only a few patients were benefited for an appreciable time (Table III).

TABLE III: RESULTS OF PALLIATIVE THERAPY

Period of Survival	No. of Cases
Died during radiotherapy	1
Died within 1 month	8
Died within 1-3 months	3
Died within 3-6 months	2
Died within 6-12 months	2
Died within 1-2 years	1
Died within 2-3 years	0
Died within 3 years	1
No follow-up	4
	22

Of the 18 patients whom we were able to follow, all except 2 died within a year. One survived for three years in spite of the fact that his anaplastic carcinoma had extended to the abdominal wall. Since the majority of these patients had far advanced disease, the relief of symptoms was difficult to evaluate, but from our experience it seemed that, on the whole, decrease in hematuria was the most impressive symptomatic improvement.

TABLE IV: RESULTS OF RADICAL THERAPY

Period of Survival	No. of Cases
No follow-up	2
0-6 months	12
6-12 months	10
12-18 months	7
18-24 months	3
2-3 years	4
3-5 years	9
5-8 years	6
	53

Table IV shows the survival results in 53 patients in the more favorable group, namely, those who loaned themselves to a more radical therapeutic approach.

Following are detailed data on the 15

TABLE V: DATA ON 4 PATIENTS WITH IRRADIATION FOLLOWED BY SURGERY

Case No.	Classification and Extent of Disease	2 MV or Co ⁶⁰ Irradiation Total Dosage	Surgical Procedure	Period of Survival
1.	Papillary carcinoma, well differentiated, Stage B ₂	Co ⁶⁰ : 6,600 r total dose in 46 days, May-July 1955	Total cystectomy in October 1955. Disease present but "walled off in bladder"	Five years
2.	Transitional-cell carcinoma, Grade III, Stage B ₂	Co ⁶⁰ : 7,000 r total dose in 51 days, June-August 1955	Total cystectomy in September 1955; tumor found at surgery	Died June 1956 in another hospital, of generalized disease in lungs and bones
3.	Transitional-cell carcinoma, Stage B ₂	Co ⁶⁰ : 2,400 r total dose in 12 days, Oct. 21-Nov. 1, 1956	Total cystectomy and bilateral ureterosigmoidostomy November 1956. No evidence of tumor	No tumor; alive 4 years
4.	Transitional-cell carcinoma, moderately well differentiated Stage B ₂	Co ⁶⁰ : 4,000 r total dose in 30 days, June 14-July 14, 1959	Exploratory laparotomy, August 1954. Resection unsuccessful. No radical changes in specimen	Died in shock, immediately after surgery

patients who survived three years and more. Two were classified as having Stage B₁ carcinoma and 13 Stage B₂ and C, and their survival over three years is encouraging. One of the patients died of arteriosclerotic heart disease eight years after completion of therapy, the other of a second primary carcinoma. Four patients are now alive without evidence of disease after five to eight years.

Of the 9 patients who survived three years, 2 had died in the meantime, 1 of heart disease with no evidence of tumor in the bladder at autopsy, the other of a second primary carcinoma in the lung, but possibly with residual disease in the bladder. This latter patient was treated for carcinoma of the lung in another hospital and died there. No autopsy was performed. Of the 7 patients who are alive, 2 are known to have recurrent or residual disease and a surgical procedure is contemplated in 1. The other 5 patients are without known evidence of disease.

The microscopic classification of the tumors in these 15 patients was as follows: 3 well differentiated papillary carcinomas with deep invasion of muscle, Stage B₂; 1 undifferentiated carcinoma, Grade IV, Stage C; 1 transitional-cell carcinoma which was classified as well differentiated with squamous metaplasia and deep invasion of muscle, Stage B₂; 2 transitional-cell carcinomas, Grade III, 1 Stage B₁ and 1 Stage B₂; 1 moderately well differentiated, Stage B₂; 7 transitional-cell carcinomas, 1

being Stage B₁, 4 Stage B₂, and 2 Stage C.

Following completion of therapy, 20 of the 53 patients showed no evidence of tumor, either by cystoscopy, transurethral biopsy, or exploratory laparotomy, while persistent tumor following irradiation was found in 23 of the cases. It has to be emphasized, however, that in some of the patients who remained free of disease for more than a year, residual disease was discovered at a later date.

Autopsy material of this group consisted of 12 cases, and some interesting findings were noted in these studies. There was histologic evidence of metaplasia in 4 cases; 2 patients were found to be completely free of disease, and in 2 disease was present but "well walled off."

Four patients of the 53 underwent a surgical procedure, 3 after completion of a full course of therapy because of recurrent or persistent disease and 1 after completion of only half of the outlined course of treatment (Table V).

The following observations were made in this group: First, it was possible to perform surgery after a dose of 4,000 to 7,000 r delivered in a period of four to seven weeks with a two-million-volt or cobalt-60 unit. While the surgical procedure was found to be difficult at times, it was not attended by severe complications. Second, microscopic examination of the specimen in 1 of the patients with recurrent disease showed the tumor to be well walled off behind a thick fibrous wall, and this patient is now

alive and well for six years. A third interesting observation was the complete disappearance of the tumor in 1 case where only one-half of the desired tumor dose had been given. The patient had interrupted the treatment and refused further radiotherapy, whereupon it was decided to treat him with surgery instead. He is alive at the time of this report, four years after the procedure, without evidence of disease.

This last case and the previously mentioned observation that some patients were free of disease for one to two years and then came back with widespread recurrences led to initiation of a new program. This was worked out by Dr. Perry Hudson, who at that time was the Director of the Department of Urology of the Francis Delafield Hospital, and by the senior author of the present paper. We felt that it might be worthwhile to try a combined radiotherapeutic and surgical approach in the group where either method alone was not likely to produce satisfactory results. It was our plan to treat such patients with a preoperative tumor dose of 3,000 r on the cobalt-60 or 2-million-volt machine and follow this procedure, after two weeks, with a cystectomy. When the disease was not confined to the bladder but had invaded perivascular tissues, we planned to give a postoperative dose of 3,000 r through opposing pelvic fields. A total of 10 patients have been treated in this fashion. Table VI gives the pertinent data.

In breaking the findings down, it has to be stated that the most interesting observation in this group was the absence of residual tumor in the microscopic specimen in 5 of the 10 patients. We unfortunately lost 2 of these 5 a short time after therapy; 1 died from peritonitis and pulmonary infection two weeks after surgery, another from an embolism two weeks after the operation. The remaining 3 are alive and well, without evidence of disease, between one and five years.

In a sixth case tumor cells were found in the perivascular fat in the specimen. This

patient received a postoperative course of therapy and is now alive four years after completion of treatment.

Three patients proved to have disease which was too far advanced to lend itself to a cystectomy: 1 had only exploratory laparotomy, as the tumor was found to be fixed to the pelvic wall. He received postoperative radiotherapy and was known to be alive one and a half years later. The other 2 patients had exenterations; 1 died in shock and the autopsy showed widespread disease; the other died one year later of widespread infection. This patient represented an interesting situation, as she had two proved primary carcinomas, one in the lung and the other in the bladder. The lung lesion had been treated by surgery one year before the bladder tumor was diagnosed. At autopsy only one area of metastatic disease was found in the third lumbar vertebra, but the origin of this metastasis could not be established with certainty. The tenth patient had residual disease in the bladder and is alive, without evidence of disease, one year after therapy.

The surgical procedures, which were carried out by Dr. Hudson after a tumor dose of 3,000 r had been delivered, were not accompanied by undue complications or side-effects in his hands, and the patients recuperated in a short time.

SUMMARY

Various approaches in the treatment of advanced carcinoma of the bladder with 2-million-volt or cobalt-60 therapy have been described and their effect on the tumor has been evaluated. We have demonstrated that in a number of patients, namely, 6 out of 53, it has been possible to eradicate the disease and to keep the patient alive and without evidence of disease for five years and longer. Of the 9 additional patients who lived longer than three years, 2 died without evidence of disease and 5 were alive and well without demonstrable disease, at the time of this report, while the remaining 2 are known to have residual or recurrent tumor.

TABLE VI: DATA ON 10 PATIENTS WITH PLANNED COMBINED RADIOTHERAPY AND SURGICAL APPROACH

Case No.	Diagnosis and Extent of Disease	Previous Therapy (Surgical or Irradiation) Yes No	Present Treatment	Surgical Procedure	Pathologic Findings After Surgery	Outcome
1.	Transitional-cell carcinoma, moderately well differentiated with deep invasion of muscle	X	2/25-3/17/55 3,000 r, total dose, Co ⁶⁰	4/19/55 Pelvic exenteration	Pathologic specimen: no evidence of tumor	5 3 55. Died of peritonitis and pulmonary infection. No evidence of disease at autopsy.
2.	Transitional-cell carcinoma, well differentiated with invasion of muscle	X	4/26-5/16/56 3,000 r, total dose, Co ⁶⁰ ; 7/12-8/1/56 3,000 r, total dose, Co ⁶⁰	5/30/56 Total cystectomy	Pathologic specimen: Tumor cells in perivascular fat	Alive and well 1961
3.	Transitional-cell carcinoma, with invasion of muscle	X	10/21-11/7/57 3,000 r, total dose, Co ⁶⁰	11/21/57 Total cystectomy, prostatectomy, and bilateral ureteral sigmoidostomy	Pathologic specimen: No evidence of disease	Alive and well 1959
4.	Transitional-cell carcinoma, with invasion of muscle	X	8/27-9/18/58 3,000 r, total dose, Co ⁶⁰	Total cystectomy	Pathologic specimen: No evidence of disease	Alive and well 1961
5.	Transitional-cell carcinoma, with invasion of muscle	X	7/3-7/24/58 3,000 r, total dose, Co ⁶⁰ ; 9/16-10/6/58 3,000 r, total dose	8/8/1958 Exploratory laparotomy only. Bladder was fixed to lateral pelvic wall	No pathologic specimen; widespread inoperable disease	Alive 1960
6.	Transitional-cell carcinoma, papillary, well differentiated. No invasion of muscle	X	12/25/59-1/19/60 3,000 r, total dose, Co ⁶⁰	Total cystectomy 2/25/60. Residual papillary carcinoma in urethra, intraepithelial, well differentiated	Pathologic specimen: Local residual disease in bladder	Alive December 1960
7.	Papillary transitional-cell carcinoma, no invasion of muscle	X	2/10-3/11/60 3,000 r, total dose, Co ⁶⁰	3/31/60 Total cystectomy; no evidence of tumor	Pathologic specimen: No evidence of disease	4 8 60. Died of embolism
8.	Transitional-cell carcinoma, with invasion of two-thirds of bladder wall. Vaginal wall free. (Second primary cancer (of lung) surgically removed one year before)	X	April 1959 3,000 r, total dose, Co ⁶⁰	Anterior exenteration	Pathologic specimen: "Necrotic tumor in bladder"	Died of infection 1/8 60. Autopsy showed metastases to L-3 only
9.	Transitional-cell carcinoma, moderately well differentiated, with invasion of muscle	X	6/14-7/14/54 3,600 r, total dose, Co ⁶⁰	Pelvic exenteration	Pathologic specimen: Tumor present without radical changes	Died in shock after surgery. Widespread pelvic disease and node metastases present at autopsy
10.	Transitional-cell carcinoma, with invasion of muscle	X	12/3-12/24/58 3,000 r, total dose, Co ⁶⁰	Cystectomy: No evidence of disease	Pathologic specimen: No evidence of disease	Alive and well 1961

All of the patients who benefited from radiotherapy suffered from tumors which could be classified as papillary and transitional-cell carcinomas of various grades, with the exception of 1 which was an undifferentiated carcinoma, Grade IV.

Ten additional patients received a com-

bination of cobalt-60 or 2-million-volt therapy with surgery. In 5 of the 10 who had a course of preoperative radiotherapy, no disease was found in the specimen. Six of the 10 are alive for two to five years after treatment. It would appear from this small group that the combined ap-

proach of supervoltage radiotherapy and surgery ought to be considered as a possibly worthwhile procedure in patients with advanced carcinoma of the bladder without distant metastases, who are in good general condition with no medical contraindication to surgery.

Francis Delafield Hospital
99 Fort Washington Ave.
New York, N. Y.

REFERENCES

- BAKER, R.: Correlation of Circumferential Lymphatic Spread of Vesical Cancer with Depth of Infiltration; Relation to Present Methods of Treatment. *J. Urol.* **73**: 681-690, April 1955.
- BROWNE, H. H., AND OGDEN, R. T.: Rotational Cobalt 60 Teletherapy of Vesical Cancer. *Am. J. Roentgenol.* **83**: 107-115, January 1960.
- BUSCHKE, F., AND CANTRIL, S. T.: Roentgentherapy of Carcinoma of the Urinary Bladder; Analysis of 52 Patients Treated With 800 kv Roentgentherapy. *J. Urol.* **48**: 368-383, October 1942.
- BUSCHKE, F., CANTRIL, S. T., AND PARKER, H. M.: Supervoltage Roentgentherapy. Springfield, Ill., Charles C Thomas, 1950.
- Cancer of the Bladder; Study Based on 902 Epithelial Tumors of Bladder in Carcinoma Registry (Am. Urol. A.). *J. Urol.* **31**: 423-472, April 1934.
- CORDONNIER, J. J., AND SEAMAN, W. B.: Betatron Therapy in Advanced Carcinoma of Urinary Bladder. *J. Urol.* **76**: 256-262, September 1956.
- CUCCIA, C. A., JONES, S., AND CRIGLER, C. M.: Clinical Impressions in 100 Consecutive Cases of Carcinoma of the Urinary Bladder Treated by Supervoltage. *J. Urol.* **79**: 99-109, January 1958.
- FLOCKS, R. H.: Treatment of Patients with Carcinoma of the Bladder. *J. A. M. A.* **145**: 295-301, Feb. 3, 1951.
- FRANKSSON, C.: Tumours of the Urinary Bladder. *Acta chir. scandinav.* Suppl. 151, 1950, pp. 1-20.
- FRIEDMAN, M.: Supervoltage (2-Mvp) Rotation Irradiation of Cancer of the Bladder. *Radiology* **73**: 191-207, August 1959.
- FRIEDMAN, M., AND LEWIS, L. G.: Irradiation of Carcinoma of the Bladder by a Central Intracavitary Radium or Cobalt 60 Source (the Walter Reid Technique). *Am. J. Roentgenol.* **79**: 6-31, January 1958.
- JEWETT, H. J.: Carcinoma of the Bladder; Influence of Depth of Infiltration on 5-Year Results Following Complete Extrication of Primary Growth. *J. Urol.* **67**: 672-680, May 1952.
- JEWETT, H. J., AND STRONG, G. H.: Infiltrating Carcinoma of the Bladder; Relation of Depth of Penetration of the Bladder Wall to Incidence of Local Extension and Metastases. *J. Urol.* **55**: 366-372, April 1946.
- MARSHALL, V. F.: A Comparison of Radiation and Surgery for Cancer of the Bladder. *J. A. M. A.* **134**: 501-507, June 7, 1947.
- MARSHALL, V. F.: Symposium on Bladder Tumors; Current Clinical Problems Regarding Bladder Tumors. *Cancer* **9**: 543-550, May-June 1956.
- MARSHALL, V. F.: Results of Radiation Therapy of Bladder Cancer. *New York State J. Med.* **48**: 875-876, April 15, 1948.
- MAYOR, G.: Le traitement du cancer de la vessie. *Urol. internat.* **1**: 25-42, 1955.
- MILLEN, J. L. E.: Results of Treatment of Bladder Cancer by Radiotherapy. *Brit. J. Urol.* **22**: 430-433, December 1950.
- ROVCE, R. K., AND ACKERMAN, L. V.: Carcinoma of the Bladder; Clinical, Therapeutic and Pathologic Aspects of 135 Cases. *J. Urol.* **65**: 66-86, January 1951.
- RUBIN, P., AND BURAN, R.: Supervoltage Irradiation in Bladder Carcinoma: 1952-1958. *Radiology* **73**: 209-224, August 1959.
- STAPLETON, J. E.: Treatment of Advanced Carcinoma of the Bladder with Two-Million-Volt Rotation Therapy. *J. Fac. Radiologists* **4**: 207-210, January 1953.
- WHITMORE, W. F., JR., AND MARSHALL, V. F.: Carcinoma of the Bladder. *S. Clin. North America* **33**: 501-515, April 1953.

SUMMARIO IN INTERLINGUA

Le Tractamento de Avantiate Carcinoma del Vesica: Un Reporto de 89 Patientes Tractate con Duo Millions Volt o con Cobalt-60 o con un Combination de Iste Typo de Irradiation e Chirurgia

Septenta-novem patientes con avantiate carcinoma del vesica esseva tractate con irradiation a duo millions volt o a cobalt-60 al Hospital Francis Delafield de New York inter januario 1951 e januario 1960. Dece alteres esseva tractate con un combination planate de radiotherapia e chirurgia.

In le prime gruppo, 22 patientes con avantiate morbo recurrente o con cognoscite metastases esseva tractate con limitate objectivos, in le spero de domar le morbo local e de render le existentia del paciente le plus indurabile possibile. Un dosage

al tumor de 3.000 r esseva delivrate in tres septimanas via grande opposite campos pelvic. Solmente paucos de iste patientes beneficiava ab le irradiation durante un appreciabile periodo de tempore. In le gruppo del 18 pro qui informaciones esseva accessibile, omnes—con 2 exceptions—moriva intra un anno. In le caso del patientes irradiate con le spero de effectuar un curation, un total dose al tumor de 4.000 a 6.000 r esseva delivrate in quatro a sex septimanas. In le majoritate del casos le dose diurne al tumor esseva 200 r. Le tolerantia immediate pro iste quantitate

50, pp. 1-26.
2-Mvp) Rot-
r. Radiology
.: Irradiation
entral Intra-
(the Walter
l. 79: 6-31.
the Bladder;
Year Results
ary Growth.
: Infiltrating
depth of Pen-
ence of Local
5: 366-372.
of Radiation
r. J.A.M.A.
on Bladder
ding Bladder
56.
Radiation
ate J. Med.
ancer de la
reatment of
J. Urol. 22:
. V.: Car-
apeutic and
65: 66-86.
upervoltage
958. Radi-
Advanced
Hillion-Volt
: 207-210.
ALL, V. F.
h America

esceva bon, e melioration del hematuria
occurreva in multe casos. Dece-cinque
de 53 pacientes superviveva tres annos o
plus. Sex esceva vive e sin signo de
morbo durante cinque annos o plus.
Quattro patientes esceva subjicite a
chirurgia post le irradiation. In 1, il
esceva trovate que le tumor esceva im-
murate detra un spisse pariete fibrose, e
iste paciente vive e se trova ben deposit sex
annos. In un altere le tumor habeva
disparite completamente. Un secunde

gruppo de patientes recipeva un planate
curso de tractamento de 3.000 r de irradia-
tion pre-operatori, sequite in duo septi-
manas per cystectomia. Quando le
morbo non esceva confinato al vesica, un
dose post-operatori de 3.000 r additional
esceva delivrate per opposite campos pel-
vic. Dece patientes esceva tractate in iste
maniera. Sex de illes vive al tempore del
presente reporto, i.e. inter duo e cinque
annos post le therapia. In 5, le specimen
microscopic monstrava nulle residue tumor.



Comparison of the Light Output of Image Intensifier Tubes¹

GEORGE C. HENNY, M.D., and JOSHUA A. BECKER, M.D.

IMAGE INTENSIFIERS are now beyond the realm of experimentation and have become an integral part of the routine equipment in diagnostic radiology. Since the day of W. E. Chamberlain's Carman Lecture, "Fluoroscopes and Fluoroscopy" (1), the need for raising image brightness to cone vision level has been generally recognized. The Westinghouse Corporation in 1949 produced the first practical model of the Coltman image-intensifier tube; Chamberlain, in our institution, Temple University, used this in clinical work. Since that time our interest in image intensification has continued and we have had many tubes available for clinical and experimental purposes. In the desire to standardize photographic procedures utilizing the image-intensifier tubes, we intercompared tubes and evaluated their responses. The data and conclusions that follow are based on both the physical and the practical operating aspects of the tubes tested.

The image intensifier is a large vacuum tube containing at the x-ray input end a fluorescent screen which converts the roentgen image into a light image. A photoelectric layer then converts the light image into an electron image. An electrostatic field accelerates the electrons and refocuses them to a sharp image at the small output phosphor layer at the other end of the tube. The output phosphor reconverts the electron image to a visible light image. In this process the original image is reduced in size about twenty-five-fold. Because of this concentration of electrons and the energy they have received from the electrical field, the viewing image is 500 to 3,000 times as bright as the image on a Patterson type B fluoroscopic screen. The light image may be directly viewed through an optical system of lenses and/or

mirrors, it may be photographed with a still or motion-picture camera, or it may be displayed *via* television. The properties of the image-intensifier tubes evaluated were mainly their responses to different qualities and quantities of incident x-ray. Image qualities, *i.e.*, contrast and detail perception, were not considered. We are now evaluating a number of the different image-intensifier television systems at present available for their "efficiency" in transmitting radiologic information; the results will be recorded in a subsequent communication.

The variables studied are: (a) the incident x-ray intensity in roentgens per minute at the input end of the intensifier, (b) the intensity of light in millilamberts at the output phosphor screen, and (c) the electron emission in microamperes by the input photoelectric screen (sometimes referred to as the "brightness level"). The tubes are operated according to the specifications of the manufacturer. To simulate operating conditions most closely, the majority of the comparisons were done with a 10-cm. Presdwood phantom in the beam adjacent to the image intensifier. The field size was adjusted to include the entire input screen of the intensifier.

A Victoreen r meter was used in the absolute determinations. Because of its operating convenience, a Radocon integrating r meter was employed in the relative comparisons. The light intensity of the output phosphor was measured with a Macbeth illuminometer with a Wratten No. 56 filter to simulate the green of the phosphor screen. A 2-mm. Al filter was placed in the x-ray beam for all measurements. Calibrations of the microammeters of the various intensifiers were checked and found to agree.

Five 5-inch Philips image-intensifier

¹ From Temple University School of Medicine (G. C. H., Department of Medical Physics; J. A. B., Department of Radiology), Philadelphia, Penna. Aided by U. S. Public Health Service Grants #CS-9438 and #CS-9681. Accepted for publication in January 1961.

tubes from nine to twenty-four months old were intercompared along with the 5-inch image-intensifier tube of a Westinghouse Cinefluorex Unit.

Tube	Date of Delivery
Philips No. 1	January 1959
Philips No. 2	January 1959
Philips No. 3	March 1959
Philips No. 4	November 1959
Philips No. 5	March 1960
Westinghouse	August 1958

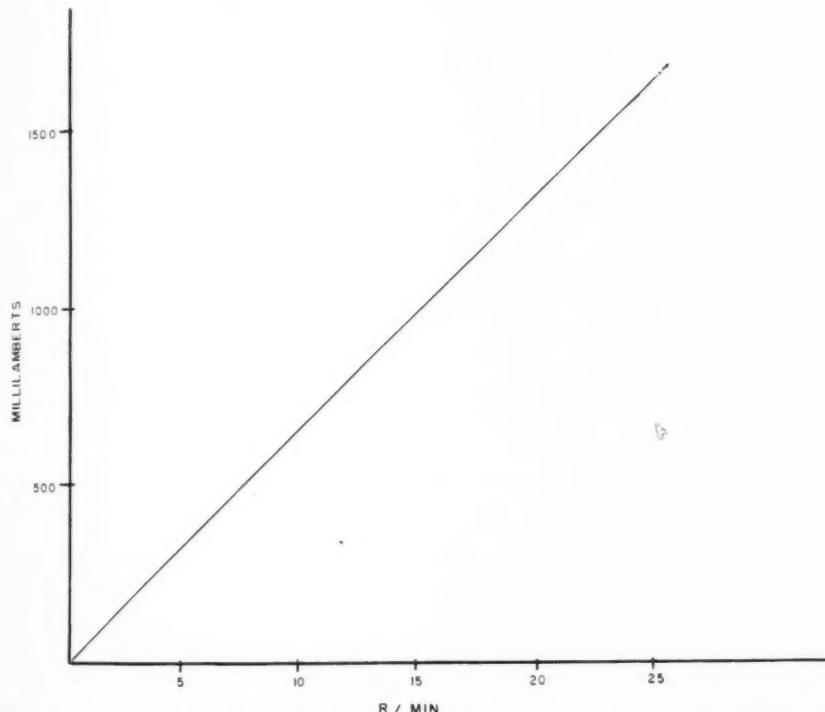


Fig. 1. Brightness of the output phosphor *vs.* r per minute at the face of the image-intensifier tube. The kilovoltage was held constant at 90 kvp and the intensity was varied by changing the milliamperes.

The optical systems (Philips "X-Ray Intensifier Fotoview," manufactured by Foto-optics, Port Washington, N. Y.) on all the Philips image intensifiers were removed so that the illuminometer measurements could be taken directly from the output screen in instances where absolute measurements were taken. This necessitated the by-passing of electrical safety equipment on the Cinefluorex.

EVALUATION

I. The response of image-intensifier tube No. 3 to incident x-rays was evaluated by continuously increasing the intensity incident upon the face of the tube by raising the milliamperes while maintaining a constant kilovoltage. In this instance, the optical system had been removed so that the output phosphor could be viewed directly. The response is essentially linear throughout the measured range from 0.01

to 25 r /min., as shown in Figure 1. This response is a characteristic of this individual tube. Other tubes have shown a fall in the rate of increase of light intensity at high x-ray inputs (at varying levels above 10 r per minute).

II. The dependence of the image intensifier on the quality of the incident x-ray was determined by varying the kilovoltage over a range normally used in

diagnostic procedures, with a constant r per minute maintained. The tube responds with increased brightness as the kilovoltage is raised to a point between 90 and 100 kv where a maximum response occurs (Fig. 2), followed by a decrease in brightness at higher kilovoltages. The initial increase is due to the greater penetration of the glass envelope and to the

the milliamperes while keeping the kilovoltage constant. There is a linear decrease in efficiency as the intensity of the incident radiation increases.

(b) Figure 3, B also shows the efficiency of the image intensifier *vs.* increase in the incident x-rays. Here, however, the intensity was raised by increasing the kilovolts while keeping the milliamperes con-

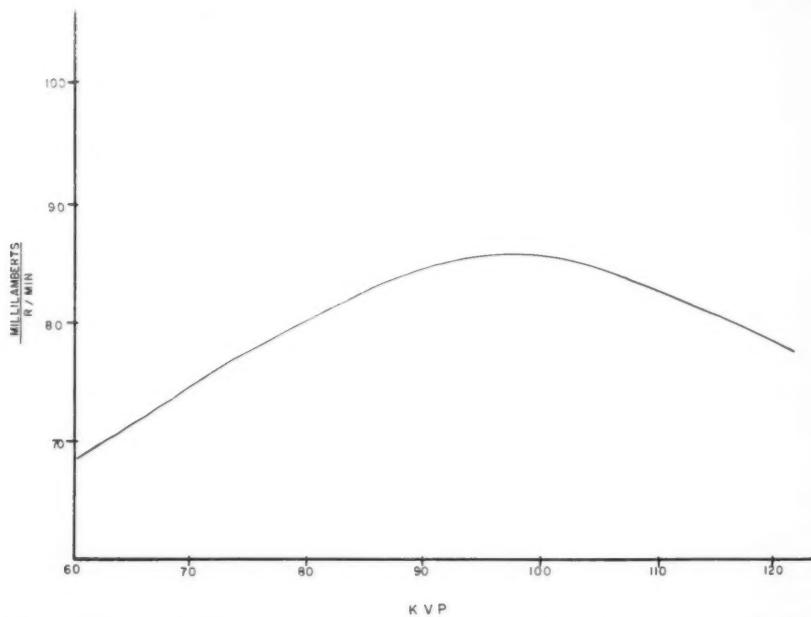


Fig. 2. Efficiency (millilamberts per r per minute) *vs.* kilovoltage when the incident intensity is maintained at 0.020 r per minute.

more efficient absorption by the input phosphor of the incident radiation. The efficiency of the input phosphor then begins to decrease as the x-rays become more penetrating, since the input phosphor is less able to convert this harder radiation into photoelectrons.

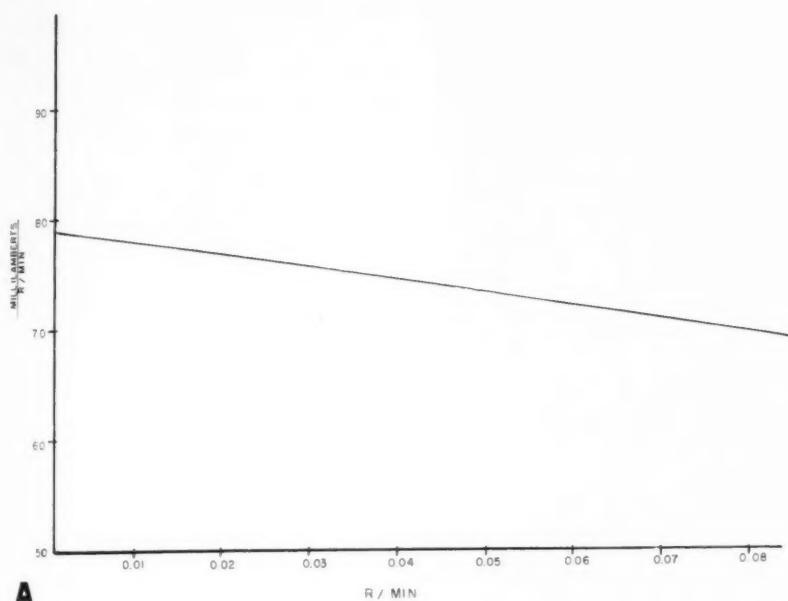
III. The "efficiency" of the tube was defined as the ratio of millilamberts to r per minute incident upon the intensifier. This ratio is a convenient way of comparing different intensifier tubes, since its reading shows the response of the tube to the incident radiation.

(a) Figure 3, A shows the efficiency of the image intensifier *vs.* increase in the incident x-rays. Intensity was raised by increasing

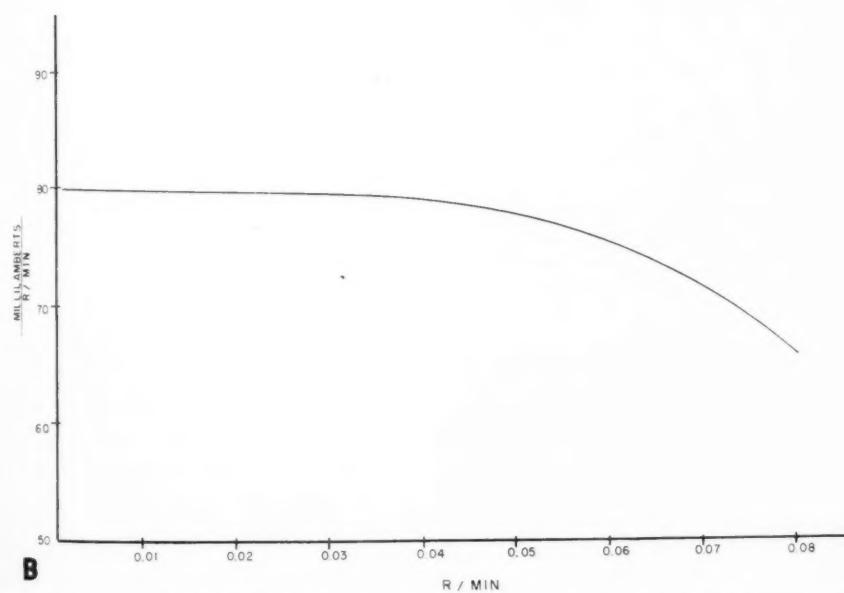
constant. There is a non-linear decrease of efficiency as the intensity and hardness of the incident radiation increases.

The curve obtained here is the summation of the effects of two variables upon efficiency—intensity and hardness. As previously shown, there is a kilovoltage range for the maximum conversion of incident x-rays into light intensity (Fig. 2) and a decreasing efficiency in converting absolute r into light intensity (Fig. 3, A). In the first portion of the curve the decreasing efficiency of the tube's response to increasing r per minute is lessened by increasing the kilovoltage. Then, when an incident x-ray level of 0.03 to 0.04 r per minute is passed (at kvp 90 to

the kilo-linear density of the efficiency increase in the , the in- the kilo-
eres con-



A



B

Fig. 3. A. Efficiency (millilamberts per r per minute) *vs.* r per minute when the kilovoltage is maintained at 90 kVp and the intensity varied by changing the milliamperes.

B. Efficiency (millilamberts per r per minute) *vs.* r per minute when the milliamperes are maintained at 0.5 and the kilovoltage varied between 60 kVp and 120 kVp.

100), both intensity and hardness combine to produce a more rapid decline in efficiency.

INTERCOMPARISON

I. The light intensity of the output phosphor screen was measured in four

tubes after the removal of the optical systems of the image intensifiers. The results are shown in Table I. Although these comparisons are at incident x-ray levels above those clinically used, extrapolation is felt to be valid, since the response of the tubes is linear in these ranges, as shown in Figure 1.

intensifier. For these measurements the optical systems were replaced. Each set of measurements was made with the same kilovoltage and milliamperage and with a 10 cm. Presdwood phantom in the incident x-ray beam.

(a) The photocathode current (microamperes) was measured and compared

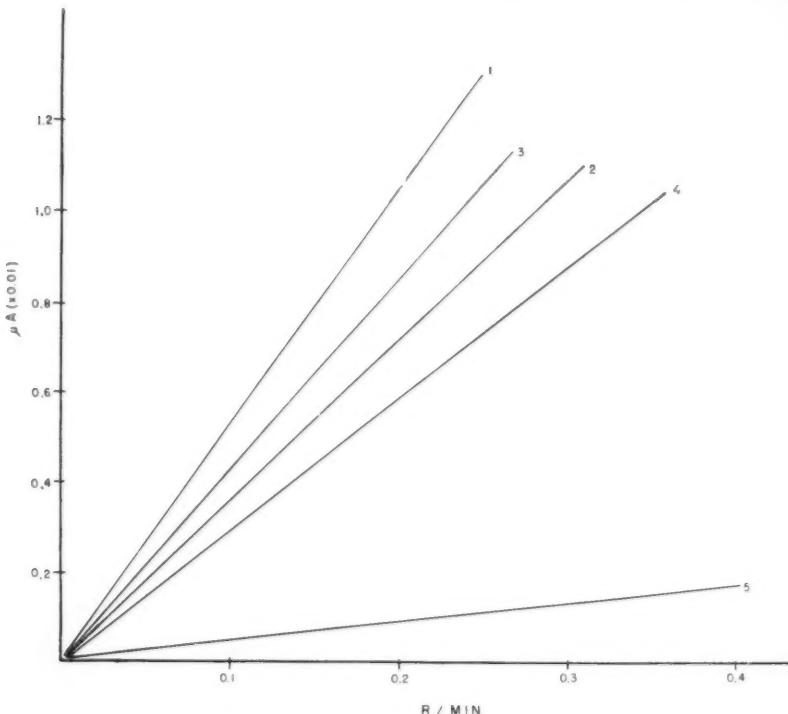


Fig. 4. The photocathode current (microamperes) *vs.* *r* per minute at the face of the image intensifier. The kilovoltage was held constant at 90 kvp and the intensity was varied by changing the milliamperes.

TABLE I: LIGHT INTENSITY OF OUTPUT PHOSPHOR SCREEN OF FOUR TUBES

	<i>r</i> per minute	Millilamberts	Millilamberts per <i>r</i> per minute*
Fluorex	1.1	29.6	26.4
Philips No. 3	1.1	49.6	45.2
Philips No. 0 (returned)	2.0	37.0	18.5
Philips No. 2	2.0	98.0	49.0

* Efficiency.

II. The photocathode current and the brightness of the output phosphor of the Philips tubes were measured in respect to the *r* per minute at the face of the image

to *r* per minute at the face of the image intensifier. Figure 4 shows the response of the input screen to the incident x-rays. The input screen of tube No. 1 is seen to be the most efficient in converting x-rays into emitted electrons. Tube No. 5 is seen to be extremely poor in this function.

(b) The brightness of the output phosphor was measured and compared to the photocathode current (microamperes). Figure 5 shows the response of the output phosphor to the electrons emitted by the input screen after their acceleration in the tube. The phosphor of tube No. 5 is

ents the
Each set
he same
nd with
the in-
(micro-
mpared

seen to be the most efficient in converting incident electrons into light.

(c) The brightness of the output phosphor was measured and compared to the x-ray incident on the face of the intensifier. Tube No. 1, as seen in Figure 6, had the best overall response. The results seen here are a combination of the responses of

milliamperes, per minute) and the image intensifier tube aspect (photocathode current, *i.e.*, microamperes) are compared to the brightness produced at the output phosphor screen. From these data, the two screens of the intensifier tubes are then evaluated.

At the normal operating level (80–100

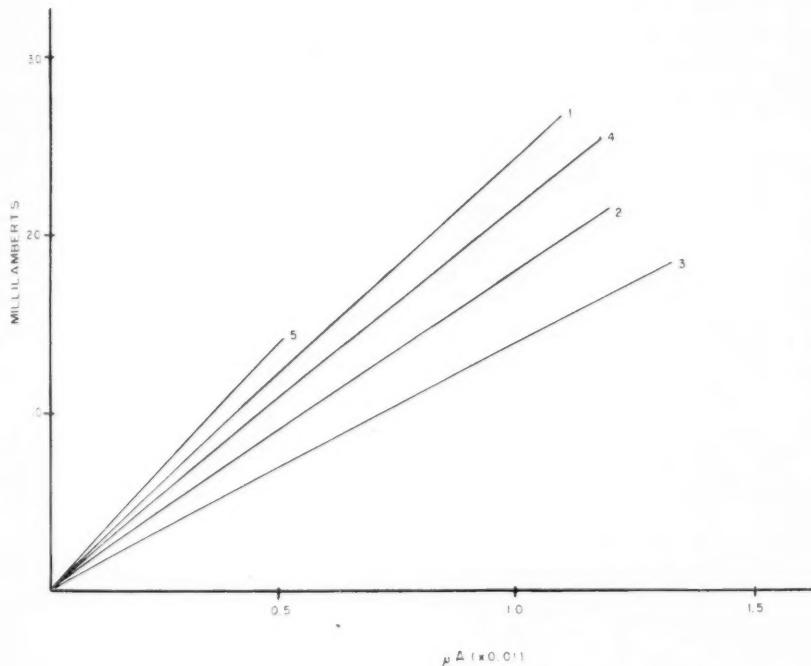


Fig. 5. The brightness of the output phosphor *vs.* photocathode current (microamperes).

image
sponse
x-rays.
n to be
ays into
seen to
the input screen and of the output phosphor. It is interesting to note that tube No. 5 has the least efficient input screen and the most efficient output phosphor. However, it falls lowest in rank in the intercomparison in this section.

SUMMARY AND CONCLUSIONS

Four image-intensification tubes are compared with respect to roentgens per minute at the primary screen *vs.* millilamberts at the secondary screen ("efficiency").

The parameters for the brightness levels from the input x-ray aspect (kilovolts,

kvp) of image-intensifier tubes variations in milliamperage and *r* per minute produce little change in the efficiency of tube operation. However, at either low or high kilovoltage, the ability of the tube to convert x-rays into light falls off.

No tube tested had both the most responsive input screen and the most responsive output phosphor. This combination would be optimal for peak efficiency. However, in final judgment, the tube with the greatest light output per incident *r* per minute ("efficiency") is the most desirable, regardless of how this effect is produced.

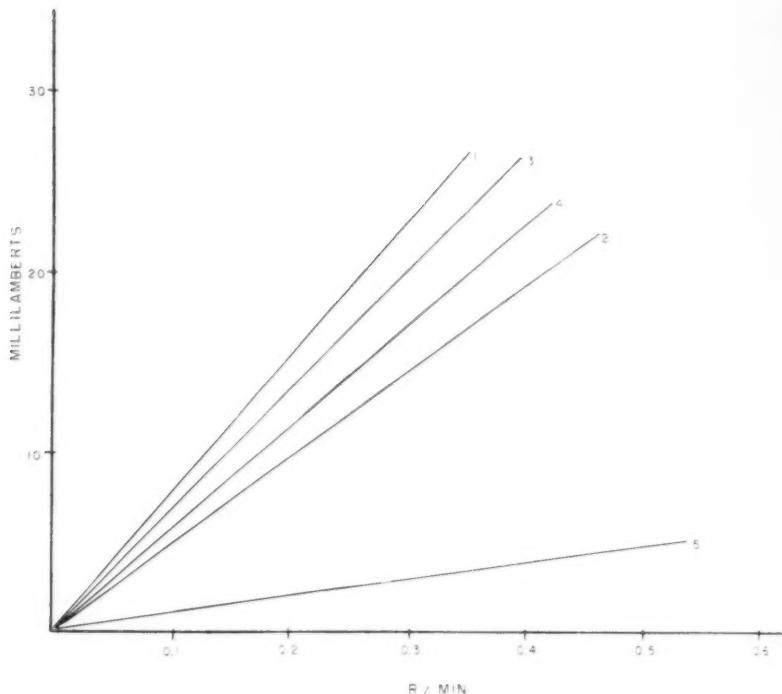


Fig. 6. Brightness of the output phosphor vs. r per minute at the face of the image intensifier. The kilovoltage was held constant at 90 kvp and the intensity was varied by changing the milliamperes.

The observations indicate that the differing "efficiencies" between tubes are directly dependent on phosphor screen efficiencies.

ADDENDUM

Since this article was submitted for publication, we have had the opportunity of evaluating the Keleket Image Intensifier with the Thomson-Houston tube at St. Christopher's Hospital for Children, the pediatric section of the Temple University Medical Center. The efficiency of this

tube was found to be 185 millilamberts per r per minute. This is considerably higher than the efficiency of the other tubes tested. The parameters of measurement for the data presented in Table I were used.

Joshua A. Becker, M.D.
Department of Radiology
Temple University School of Medicine
Philadelphia 40, Penna.

REFERENCE

1. CHAMBERLAIN, W. E.: Fluoroscopes and Fluoroscopy. Carman Lecture. Radiology **38**: 383-413, April 1942.

SUMARIO IN INTERLINGUA

Comparation del Rendimentos de Lumine de Tubos de Intensification del Imagine

Es listate quattro tubos de intensification del imagine con roentgen per minuta al ecran primari comparete con millilambert al ecran secundari ("efficacia").

Le parametros del nivellos de intensitate luminari del tubos de intensification del

imagine ab le aspecto de radios X (i.e., kilovolt, milliampere, e roentgen per minuta) e ab le aspecto del tubo de intensification del imagine (i.e., corrente photocathodic, in microampere) es comparete con le intensitate luminari producite como

rendimento del ecran phosphore. A base de iste datos, le duo ecrans del tubos de intensification es alora evalutate.

Al nivello de operation normal (80 a 100 kvp) de tubos de intensification del imagine, le factores technic de milliampere e roentgen per minuta produce pauc alteration in le efficacia del operation del tubos. Tamen, tanto a basse como etiam a alte kilovoltage, il occorre un declino in le capacitate del tubo de converter radios X in lumine. In plus, le tubos non es capace de mantener lor "efficacia" in le normal region diagnostic, sed iste factor es minime e pote esser negligeite.

Nulle del tubos testate habeva le plus responsive ecran de introito e simultaneamente le plus responsive phosphoro de rendimento. Un tal combination esserea optimal in le interesse del maximo de efficacia. Sed, in le judicamento final, le tubo le plus desirabile es le tubo con le plus grande rendimento de lumine per roentgen incidente per minuta (i.e., le tubo con le plus grande "efficacia"), sin reguardo al medio per que iste efecto es producite.

Le observationes indica que le differencias de "efficacia" inter differente tubos depende directemente del efficacia del ecran de phosphoro.



A Technic for Cross-Calibration of X-Ray Units Utilizing Half-Value-Layer Determinations¹

LEON PAPE, M.S., S. BAKER, R.T., and HYMAN L. GILDENHORN, M.D.

IN RADIOGRAPHIC installations of more than one x-ray unit the need to reproduce a film technic with different units makes it necessary that they be cross-calibrated. In standard practice the establishment of a film technic requires that visual examination be made of representative films for various anatomical structures. Because of possible inconsistencies in the physical calibration factors of x-ray units, as reported in a previous paper (1), the establishment of a set of technical factors for one apparatus would not necessarily apply to a second. The process of trial and error must be repeated with each one, and this results, in addition to the time and effort required, in undesirable patient exposure.

In principle, the quality of a film depends on beam energy and intensity, with all other things being constant. A knowledge of these two factors for any individual apparatus, therefore, should suffice to establish radiographic technics based on an established technic chart for another unit. A system for providing this type of cross-calibration was suggested in the authors' earlier paper. Incidentally, the use of half-value layer and output determinations for the establishment of film technic is not limited to interdepartmental standardization. The possibility exists that other departments would also be able to duplicate film qualities by this means. Simply stated, an x-ray unit must first be calibrated for technical factors in the usual manner of visual evaluation. This unit serves as the standard and it is then possible to calibrate any additional units without application of visual methods, purely by virtue of the comparison of half-value layer and output. The situations in which calibration of radiographic installations becomes necessary include the following:

(a) change of tubes or other parts of a unit, (b) replacement of an installation, and (c) the addition of new units to an existing department or the creation of an entirely new department.

METHOD

Three x-ray units were studied, the conditions under which measurements were made being maintained constant. Half-value layer determinations were made with aluminum filters with a Landsverk 200-mr pocket chamber calibrated for energy dependence at the Landsverk factory. The values were plotted for each of the units on a single graph, so that the effective kilovoltage for equivalent half-value layer could be readily determined (see Fig. 1). After half-value layer determinations were made, the output of each x-ray unit was measured with the Landsverk chamber at an equivalent kilovoltage as determined from the plot of half-value layers. A plot of output per 100 milliampere-seconds at equivalent kilovoltage is shown in Figure 2. After establishment of half-value layer and output equivalences, the next step was to take one of the units as a standard and establish a set of technics which produced visually acceptable roentgenograms. From this standard technic chart a series of charts for each of the units cross-calibrated was then produced, with use of the data of half-value layer and output determinations. A simplified version of a chart for a few radiographic studies utilizing this method is shown in Figure 3.

RESULTS

An initial check on the reliability of the calibration was made with a step wedge. Figure 4 shows the appearance of the step-wedge radiographs obtained with the

¹ From the Department of Radiology (L. P., Physicist) and the Department of Diagnostic Roentgenology (S. B., Supervisor; H. L. G., Chief), City of Hope Medical Center, Duarte, Calif. Accepted for publication in January 1961.

factors selected by the above method. A hip specimen (Fig. 5) was utilized to produce a further check on comparability of the roentgenographic quality. Films were then obtained of an extremity, pelvis, and lumbar spine, with the appropriate factors for each radiographic installation. The good degree of reproducibility of film technic is demonstrated in Figures 6-8.

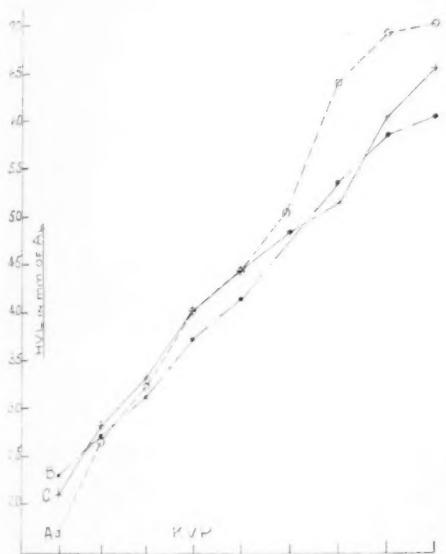


Fig. 1. Plot of half-value layer in millimeters of aluminum vs. peak kilovoltage for three radiographic installations, A, B, and C.

DISCUSSION

In the utilization of this technic for cross-calibration it is necessary to recognize an inherent limitation. This stems from the fact that milliampere-second values established by the data can at times be only approximated, because of the limited number of panel settings for milliamperage and time. For example, the data might call for an output corresponding to a setting of 6 milliampere-seconds, whereas the closest value available from the panel settings would be 5 milliampere-seconds.

The discrepancy between the available and desired outputs may be compensated for in part by a small change in the half-value layer. An example of the problem

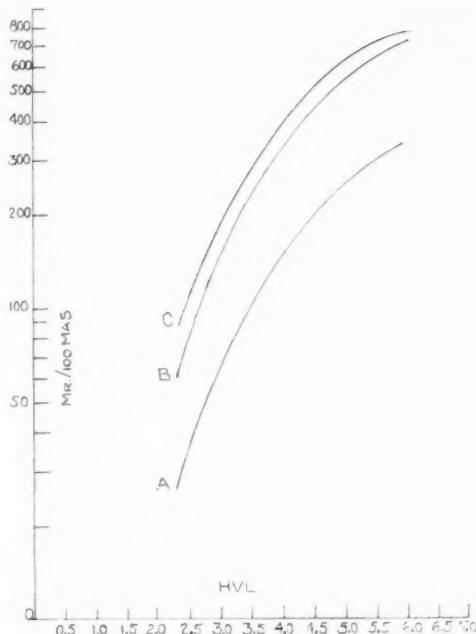


Fig. 2. Plot of log of milliroentgens per 100 milliampere-seconds vs. half-value layer in millimeters of aluminum for radiographic units, A, B, and C.

which may arise in matching film technics is demonstrated in Figure 8, where one of the radiographs is slightly lighter than the others.

In addition, there are possible inaccuracies in timer function and calibration of milliampere station as noted earlier. Where such inaccuracies introduced an error greater than the variation produced because of panel-setting limitations, a correction factor was applied to the data.

One would expect from theoretical considerations that the curves of half-value layer vs. kilovoltage would be smooth. The discrepancies demonstrated in Figure 1 are due to the inaccuracies of the kilovolt station settings on the different generators. This is particularly apparent in the range of 100 to 110 kv, where Units A and C show a sharp discontinuity. Figure 9 shows the comparability of films made on Unit A at 93 kv, Unit B at 103 kv, and Unit C at 106 kv.

It is worthwhile to consider whether the use of half-value layer and roentgen output

X-RAY UNIT	PART	POST.	Ma	TIME sec.	DISTANCE	Cm	Kv	HVL mm al.	Output Mr.
A	Shoulder	AP	100	1.0	40"	10	58	3.1	80
B	"	"	"	0.4	"	"	62	3.2	82
C	"	"	"	0.4	"	"	56	3.1	82
<hr/>									
A	Cervical	AP	100	1.0	40"	12	63	3.3	98
B	"	"	"	0.4	"	"	66	3.5	96
C	"	"	"	0.4	"	"	60	3.3	96
<hr/>									
A	Pelvis	AP	100	1.0	40"	21	77	4.3	177
B	"	"	"	0.5	"	"	79	4.1	175
C	"	"	"	0.4	"	"	76	4.2	174
<hr/>									
A	Lateral Chest	semi ax.	100	1.0	40"	20	93	5.5	300
B	"	"	"	0.5	"	"	103	5.4	303
C	"	"	"	0.4	"	"	106	5.7	299

Fig. 3. A simplified technic chart for three radiographic units, A, B, and C.

in the calibration of an x-ray unit has any advantage over the use of kilovoltage and milliamperage. The two latter refer to the operating characteristics of the tube. These factors in themselves do not take into consideration tube envelope, characteristics of the target, voltage drop in the cables, and added filtration, all of which may vary in different installations and affect the final quality of the x-ray

beam. The quality of the beam may vary, therefore, even though identical kilovolt-milliamperage settings are being utilized. While it is true that half-value-layer designation is not a complete description of the spectral distribution of energy in a heterogeneous beam, it is more accurate than kilovoltage alone, so that in practice technic factors based on half-value layer and roentgen output should be more nearly

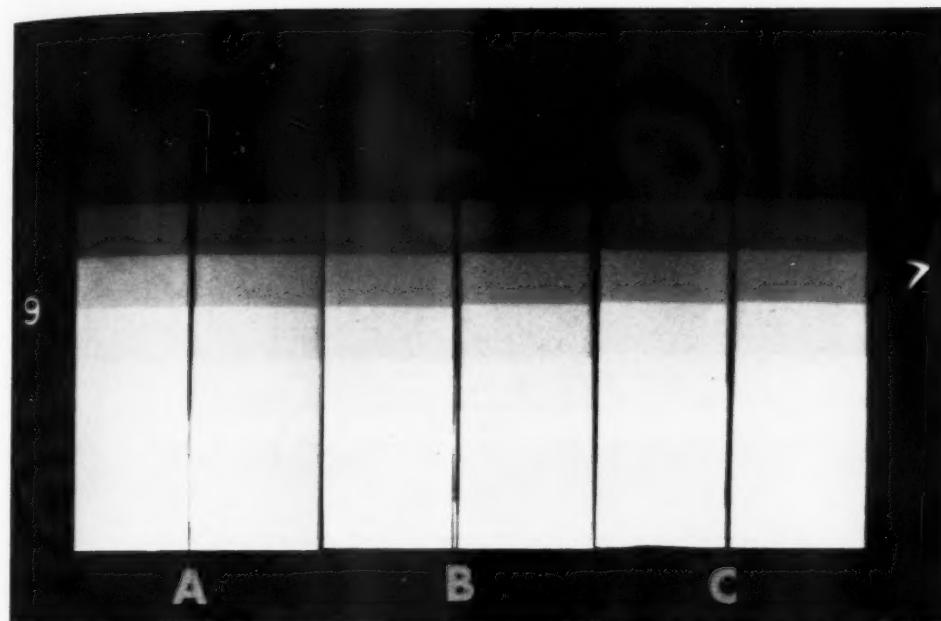


Fig. 4. Aluminum step-wedge patterns obtained at a 72-inch distance utilizing the following settings on the three radiographic units to obtain the closest available half-value layers and roentgen outputs: A, 58 kv at 100 mas. B, 62 kv at 40 mas. C, 56 kv at 40 mas.



Fig. 5. Films of a disarticulated hip specimen, obtained on units A, B, and C at a 40-inch distance. A, 58 kv at 100 mas. B, 62 kv at 40 mas. C, 56 kv at 40 mas.

vary, volt-lized. design of the hetero-
nuclear practice layer early

identical from machine to machine, irrespective of such conditions as tube envelope, target, etc.

It would appear possible to establish radiographic standards which can be used universally in the development of technic

charts for individual radiographic installations. For example, a central laboratory sponsored by an institution such as the American College of Radiology or the National Bureau of Standards could determine optimum technic factors and

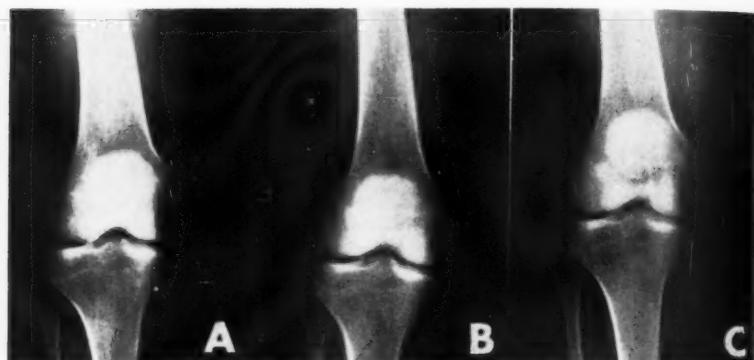


Fig. 6. Films of a knee made with the following settings at a 42-inch distance: A, 58 kv at 100 mas. B, 62 kv at 40 mas. C, 56 kv at 40 mas.



Fig. 7. Films of a pelvis made with the technic factors listed in Fig. 3.



Fig. 8. Films of a lumbar spine made with the following factors: A, 77 kv at 200 mas. B, 79 kv at 100 mas. C, 76 kv at 100 mas.

supply this information in terms of the half-value layer and roentgen output required for their reproduction. Any installation might then be calibrated to this

standard without the use of trial-and-error patient exposure.

The ability to reduce or eliminate the need for patient or personnel exposure in

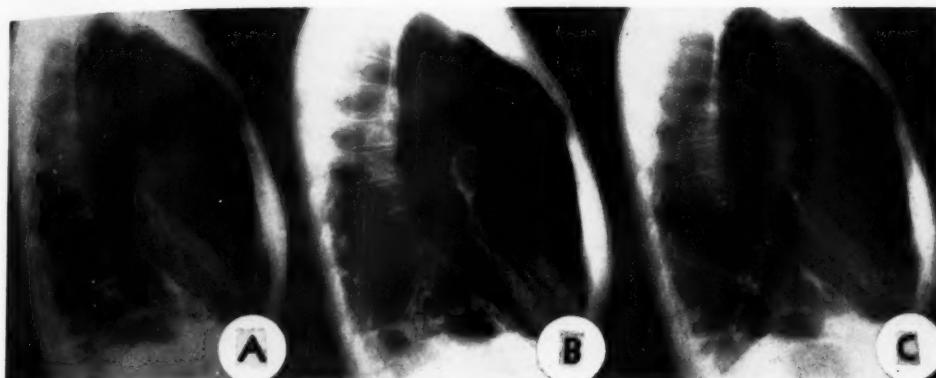


Fig. 9. Films of a lateral chest made at the following factors: A, 93 kv at 50 mas. B, 103 kv at 25 mas. C, 106 kv at 20 mas.

obtaining calibration for technic charts adds to the desirability of this method. As a further corollary it might be possible to replace kilovoltage and milliamperage settings on x-ray generator control panels with settings of half-value layer and roentgen output. It is apparent that careful calibration of x-ray units in these factors would be required to establish such a program (2).

SUMMARY

1. A method for cross-calibration of radiographic installations, utilizing half-value layer and roentgen output, has been devised. This enables reproduction of a given film quality on multiple x-ray units. 2. The procedure provides for a pos-

sible system of universal calibration of radiographic installations.

3. A major benefit derived from this system is the reduction or elimination of patient and personnel exposure.

4. The comparability of radiographs taken on different units cross-calibrated in this manner is demonstrated.

Hyman L. Gildenhorn, M.D.
1500 E. Duarte Rd.
Duarte, Calif.

REFERENCES

1. GILDENHORN, H. L., REHMAN, I., PAPE, L., AND BAKER, S.: Standardization of Physical Factors in Radiographic Exposures. *Radiology* **75**: 262-267, August 1960.
2. TROUT, E. D., KELLEY, J. P., AND LUCAS, A. C.: Determination of Half-Value Layer. *Am. J. Roentgenol.* **84**: 729-740, October 1960.

SUMMARIO IN INTERLINGUA

Un Technica pro le Calibration Cruciate de Installationes Roentgenographic, a Base de Determinaciones del Spissitates de Medie Valor

Esseva elaborate un metodo pro le calibration cruciate de installationes roentgenographic a base de determinationes del spissitates de medie valor e del rendimentos de roentgen. Un apparatura a radios X, calibrate pro factores technic in le maniera usual, es prendite como standard, e apparaturas additional es calibrate exclusivamente a base de comparationes del spissitates de medie valor e del rendimentos de roentgen. Iste technica rende

possible le reproduction de un qualitate particular de pellicula per medio de multiple apparaturas e provide possibilmente un sistema de calibration universal pro installationes radiographic. Un major beneficio es le reduction o elimination del exposition pro paciente e personal.

Es demonstrate le comparabilitate de radiographias obtenite per differente apparaturas tractate con iste metodo de calibration cruciate.

Modification of Radiation Responses of Tissue by Colchicine

Effects on Mouse Hair Roots¹

MELVIN L. GRIEM, M.D., FREDERICK D. MALKINSON, M.D., and PETER H. MORSE, A.B.

SEVERAL RECENT reviews have described the effects of various chemical and physical agents in modifying radiation responses in normal tissues and tumors (1-3). The observation that irradiation induces profound morphologic changes in animal and human hairs (4, 5) has provided a useful experimental device for the screening of such agents in rodents (6).

At any given time areas of skin in rats and mice can be found in which most of the hair follicles are in the resting phase of the hair cycle. These telogen hair follicles are mitotically inactive and are insensitive to radiation (4). If the resting hair is disturbed by plucking, its follicle becomes active and a growing (anagen) hair is formed which is highly radiosensitive. When anagen hairs are irradiated, dysplastic changes in the shafts and atrophy of the bulbs occur, the number of hairs affected being proportionate to the dose of radiation sustained.

Recent experiments in rats and mice have shown that anagen hairs also undergo profound atrophic and dysplastic changes following intraperitoneal administration of large doses of colchicine (7). Since these microscopic changes strongly resemble alterations in human hair induced by x-ray irradiation (5), the rodent hair indicator system was utilized to determine the possible synergistic role played by colchicine in increasing these x-ray effects. Our chief interest centered on the application of positive findings to the therapeutic implications of altering the radiosensitivity of certain forms of malignant growth by prior administration of colchicine.

METHODS

The studies were carried out on adult



Fig. 1. Mouse with hair plucked from both haunches.

female mice of the Carworth Farms No. 1 strain. In these animals the hair cycle lasts for seventeen to twenty days from earliest anagen to the onset of telogen. Hairs were completely plucked from both haunches of all animals at the start of each experiment, one haunch being used for examination of the effects of colchicine and irradiation, and the other for examination of colchicine effects alone (Fig. 1). Occasional mice showing areas of newly growing hairs which were not easily removed were discarded from the study.

The mice received x-ray irradiation on the tenth day after initial plucking, and four days later the newly growing hairs

¹ From the Department of Radiology, Department of Medicine (Section of Dermatology), and Argonne Cancer Research Hospital, operated by the University of Chicago for the United States Atomic Energy Commission, University of Chicago, Chicago, Ill. Presented at the Forty-sixth Annual Meeting of the Radiological Society of North America, Cincinnati, Ohio, Dec. 4-9, 1960.

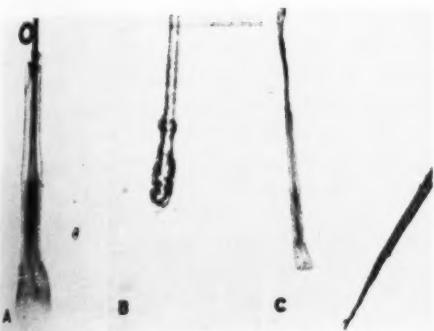


Fig. 2. A. Anagen hair. B. Telogen hair. C. Dysplastic hair.

in the control and treatment areas were plucked. These hairs were then floated on a shallow layer of water covering the bottom of a 5.5×1.5 cm. glass Petri dish which had been scored in grid pattern on its underside. The hairs were examined with a binocular dissecting microscope at $45\times$ magnification with transmitted blue light. For each animal the following stages of hair growth were recorded and counted for the "differential hair count": normal anagen, dysplastic, catagen (hairs transitional between anagen and telogen), and telogen (Fig. 2).

Two persons similarly trained performed the hair counts and their results were consistently in close agreement, although it is possible that the criteria for scoring dysplastic hairs may vary slightly from one individual to another. In our experience this variation appears to be constant for each observer. For this reason the same person performed all counts in a given experiment. During each series of counts a rotational sequence of control and treated animals was used to minimize observer bias, fatigue, and criteria variation.

Initial studies of radiation changes in the hairs produced at different dosage levels revealed a reliable and reproducible sigmoid curve for the production of dysplastic hairs. In these preliminary experiments radiation was administered with a Machlett OEG-60 tube operating at 50 kv and 30 ma with 2 mm. of aluminum added filtration. This produced 387 r per minute surface dose at a focal skin distance of

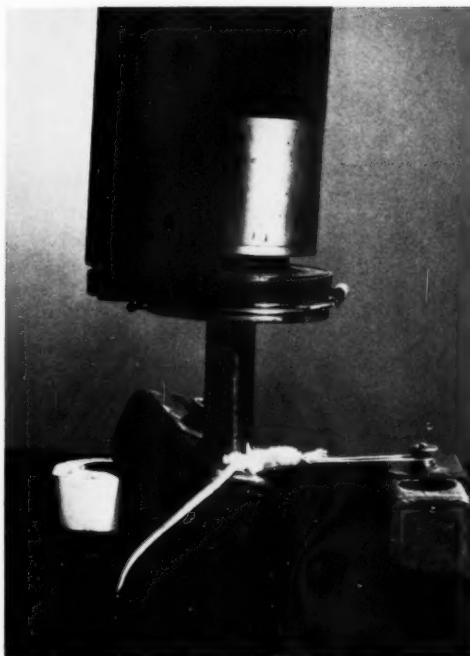


Fig. 3. Mouse in treatment position.

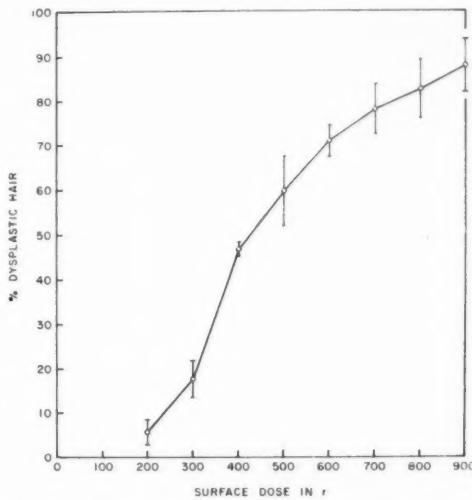


Fig. 4. Dose response curve for production of dysplastic hair in mice with a single surface dose.

11 cm. and a beam quality of 1.2 cm. half-value depth in tissue. Adequately shielded animals were treated individually and without anesthesia (Fig. 3).

The results of this experiment are shown

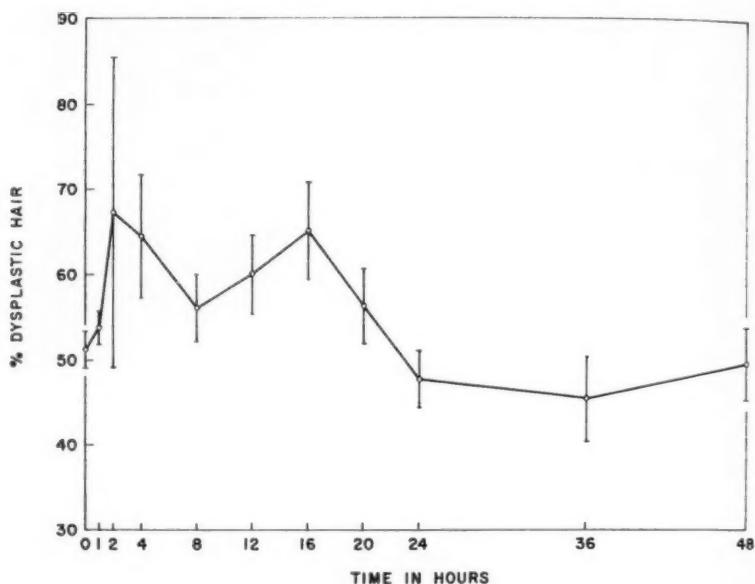


Fig. 5. The first experiment showing the effect of varying the time interval between injection of colchicine and administration of x-rays on the production of dysplastic hair.

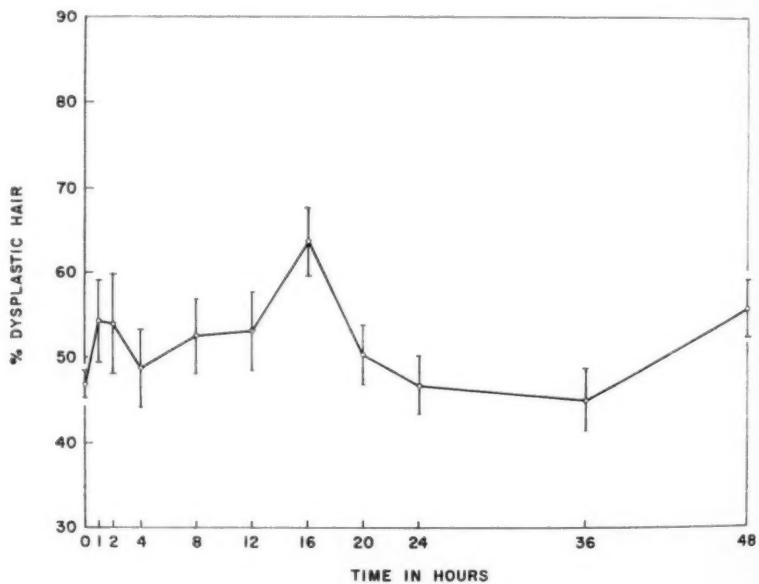


Fig. 6. The second experiment showing the effect of varying the time interval between injection of colchicine and administration of x-rays on the production of dysplastic hair.

in Figure 4. Each point on the graph represents the average percentage of dysplastic hairs in 5 animals. For each animal 100 hairs were counted from the

treated flank and 100 hairs from the control or unirradiated flank. A large number of catagen and telogen hairs from the control and irradiated flanks yielded poor

correlation between the dosage of irradiation and dysplasia. Since less than 5 per cent of the animals showed great numbers of these transitional and resting hairs, the results in such mice could be discarded without appreciably affecting the sample size. When a surface dose of 400 r was used, between 46 and 52 per cent dysplastic hairs were consistently found among 500 hairs counted. This same radiation dosage was then used in the animals treated with colchicine, so that both protective and synergistic effects of the chemical could be studied.

Colchicine² was administered intraperitoneally at a dosage of 1 mg./kg. (In the Carworth Farms No. 1 mouse 5 mg./kg. was found to be the LD 50 for this drug.) At successive intervals after the injection of colchicine, a constant dosage of radiation was administered to different groups of animals, each group being irradiated only once. The percentage of damaged hairs was plotted graphically as a function of the time interval between the administration of colchicine and irradiation.

RESULTS

The results of two separate experiments are shown on Figures 5 and 6. The vertical lines on the graphs represent the standard deviation for each point. As in the preliminary studies with x-ray irradiation alone, each point on a graph represents the average number of dysplastic hairs from a single group of 5 mice. For every animal a differential hair count was performed on 100 hairs each from the irradiated flank and from the control flank. Hairs from the control (unirradiated) flank were counted because colchicine administration alone may produce dysplastic hairs. When 1 mg./kg. of colchicine was given intraperitoneally, the control flank in all animals examined showed less than 2 dysplastic hairs/100 hairs, and in over half the animals no



Fig. 7. Patient with mycosis fungoides.

dysplastic hairs were found in the control area.

Both graphs reveal a significant synergistic effect when the colchicine injection is followed by irradiation after an interval of sixteen hours. Although there was a suggestion of synergistic action by colchicine at two-, four-, and twelve-hour intervals in one study, this effect was not confirmed in the other. Both graphs, however, show a decreased response at the end of twenty-four hours after the earlier sixteen-hour peak.

No protective effect of colchicine was observed in these studies.

CLINICAL APPLICATIONS

These preliminary observations having suggested that there might be a cyclic relationship between colchicine and irradiation, a patient with generalized mycosis fungoides in the infiltrative and tumor stages was studied using a treatment method suggested by Friedman (8). This patient was unresponsive to surface doses of 600 r in a single exposure given at 150 kv and 50 cm. focal skin distance with 3 mm. aluminum added filtration. Higher doses of 800 and 1,000 r seemed similarly ineffectual (Fig. 7). Three milligrams of colchicine was given intravenously and a single surface dose of 600 r was given through successive 10 × 10 cm. portals every four hours for sixteen hours. Treatment results are seen in Figures 8-10. The four-hour and eight-hour portals

² Colchicine was kindly supplied by Dr. G. W. Irwin of the Lilly Research Laboratories. The drug was used as provided, each ampule containing 1 mg. of colchicine in 2 c.c. of aqueous solution.

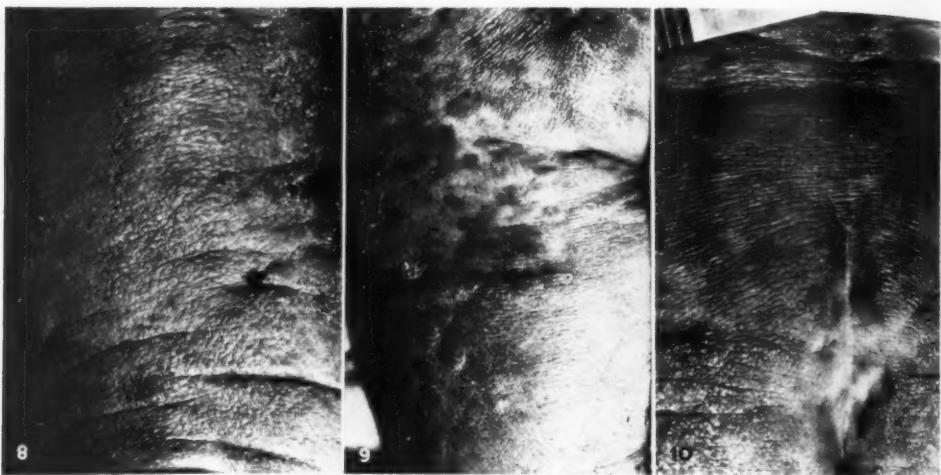


Fig. 8. Appearance of skin two weeks after treatment by colchicine followed by a single surface dose of 600 r four hours later.

Fig. 9. Appearance of skin two weeks after treatment by colchicine followed by a single surface dose of 600 r eight hours later; lower port; twelve hours later, upper port.

Fig. 10. Appearance of skin two weeks after treatment by colchicine followed by a single surface dose of 600 r sixteen hours later.

showed no essential change, but there was a definite response at twelve hours, while the most striking result was observed at sixteen hours (Fig. 10). Combined treatment using the sixteen-hour interval between colchicine administration and irradiation was repeated a number of times for other involved sites, and a good response was noted on each occasion.

Following these observations, we have selected a number of patients with unresponsive tumors for clinical trial. So far it has been found that for these patients a single intravenous dose of 4 mg. of colchicine can be given twice weekly for four weeks without serious difficulty. Occasionally there has been a transitory drop in the leukocyte count with a marked shift to the immature forms of the granulocytic series. In one patient, diarrhea was observed, but this subsided when the drug was discontinued. Tumor doses of 400 to 500 rad per treatment are tolerated when combined with colchicine pretreatment.

DISCUSSION

In the past a number of reports have appeared in the literature describing the

combined use of colchicine and irradiation for the treatment of tumors (9-12). Since it was known that colchicine interrupts cellular mitosis in the stage of metaphase, the earlier studies were based on the supposition that ionizing radiations exerted the most harmful effects on mitotic chromosomes. More recent work, however, indicates that the most radiosensitive stage of mitosis is early prophase, while the stage of metaphase is radioresistant (13). Although several different techniques for investigating the combined effects of colchicine and x-ray therapy have been employed, the results are equivocal. Furthermore, it appears that no attempt was made to correlate the time of administration of the drug and the subsequent irradiation. The most difficult problem faced by previous investigators was the lack of a suitable biological indicator system which would lend itself to objective measurements of the synergistic tissue effects of colchicine and x-ray irradiation in contrast to the use of either agent alone. This problem now appears to have been solved satisfactorily by the technic of microscopic examination of newly plucked hairs described above.

The experimental findings reported here

indicate that colchicine and x-ray irradiation produce a synergistic effect on atrophy and dysplastic changes in the hair matrix and hair shaft, and that these alterations are observed only when the administration of colchicine precedes irradiation by sixteen hours. The importance of this observation is emphasized by the fact that no other time interval studied consistently showed significant colchicine effects. The suggestion in Figures 5 and 6 that there may be additional time peaks in the range of two, four, and twelve hours is not statistically confirmed.

The mechanism of the synergistic action of colchicine and irradiation is presently under study. It is possible that colchicine acts by marshalling a relatively large number of cells into the radiosensitive stage of early prophase at the critical time period for irradiation. This action would be influenced, however, by the prolonged period of metaphase arrest and some degree of cellular degeneration which usually follows colchicine administration. It is perhaps more likely that greater hair damage results from the synergistic effects of two related or unrelated forms of cellular injury separately induced by colchicine and irradiation, independent of colchicine's anti-mitotic properties.

Whether other normal or abnormal tissues will respond similarly to the combined use of colchicine and x-ray irradiation is not yet known. It has been shown, however, that in both tumor-bearing human beings and laboratory animals there is diminished urinary excretion of colchicine following the administration of the C^{14} -labeled drug (14). This strongly suggests that the absorption and metabolism of administered colchicine differ in man and animals afflicted with tumors.

The responsiveness of a variety of experimental tumors as well as a smaller number of advanced neoplasms in man is now under study. The therapeutic results noted in the original patient with mycosis fungoides have already been described, and it is of interest that the best treatment response was obtained only within the same

sixteen-hour period separating colchicine administration and x-ray irradiation that was found to be critical in the experimental work on mice.

SUMMARY

1. The technic for microscopic examination of rodent hairs has been used to determine whether colchicine exerts a synergistic effect on dysplastic changes in growing hairs induced by local x-ray irradiation.

2. The experimental findings indicate that significant synergism occurs, but only when a specific time interval of sixteen hours separates colchicine administration from x-ray irradiation. No other time interval studied consistently exerted a similar effect.

3. No protective action of colchicine was noted in these studies.

4. Increased responsiveness to x-ray irradiation following intravenous administration of colchicine was observed in a single patient with mycosis fungoides.

Argonne Cancer Research Hospital
950 E. 59th St.
Chicago 37, Ill.

REFERENCES

1. ANDREWS, J. R., AND SNEIDER, S. E.: The Modification of the Radiation Response. *Am. J. Roentgenol.* **81**: 485-497, March 1959.
2. KAPLAN, H. S.: Recent Experimental Contributions to Radiotherapy. *Am. J. Roentgenol.* **80**: 822-832, November 1958.
3. SELAWRY, O. S., CARLSON, J. C., AND MOORE, G. E.: Tumor Response to Ionizing Rays at Elevated Temperatures. *Am. J. Roentgenol.* **80**: 833-839, November 1958.
4. GEARY, J. R., JR.: Effect of Roentgen Rays During Various Phases of the Hair Cycle of the Albino Rat. *Am. J. Anat.* **91**: 51-105, July 1952.
5. VAN SCOTT, E. J., AND REINERTSON, R. P.: Detection of Radiation Effects on Hair Roots of the Human Scalp. *J. Invest. Derm.* **29**: 205-212, September 1957.
6. GRIEM, M. L., STEIN, J. A., REINERTSON, R. E., REINERTSON, R., AND BROWN, B. R.: Comparison of Effects of Triiodothyronine and I^{131} -Induced Hypothyroidism on Radiation Effects in Hair Roots. *Radiation Res.* **15**: 202-210, August 1961.
7. MALKINSON, F. D., AND LYNFIELD, Y. L.: Colchicine Alopecia. *J. Invest. Derm.* **33**: 371-384, December 1959.
8. FRIEDMAN, M., AND PEARLMAN, A. W.: Time-Dose Studies in Irradiation of Mycosis Fungoides; Iso-Effect Curve and Tumor Lethal Dose. *Radiology* **66**: 374-378, March 1956.
9. GUYER, M. F., AND CLAUS, P. E.: Irradiation of Cancer Following Injection of Colchicine. *Proc. Soc. Exper. Biol. & Med.* **42**: 565-568, November 1939;

Destructive Effects on Carcinoma of Colchicine Followed by Distilled Water. *Proc. Soc. Exper. Biol. & Med.* **43**: 272-274, February 1940.

10. BROWN, W. O.: Effect of Colchicine on Human Tissues. *Arch. Path.* **29**: 865-866, 1940.

11. LEVINE, M.: The Action of Colchicine on Cell Division in Human Cancer, Animal, and Plant Tissues. *Ann. New York Acad. Sc.* **51**: 1365-1408, March 23, 1951.

12. HUANT, E.: Action de la colchicine sur la radiosensibilité des tumeurs malignes. *Gaz. hôp. Paris* **15**, 1944; Nouvelles considérations quant à l'action de la colchicine sur la radiosensibilité des tumeurs. *Gaz. hôp. Paris* **15**: 230, 1944.

13. KOLLER, P. C.: Chromosome Breakage. [In] *Progress in Biophysics and Biophysical Chemistry*, edited by J. A. V. Butler and J. T. Randall. New York, Academic Press, Inc., Vol. 4, 1954, pp. 195-243. *Symposium on Chromosome Breakage*. London, Oliver and Boyd, 1953.

14. WALASZEK, E. J., KOCSIS, J. J., LEROY, G. V., AND GEILING, E. M.: Studies of the Excretion of Radioactive Colchicine. *Arch. internat. pharmacodyn.* **125**: 371-382, May 1, 1960.

SUMMARIO IN INTERLINGUA

Modification del Responsa a Radiation in Tissu per Colchicina: Effectos in Radices de Capillo Murin

Capillos crescente de mus responde al roentgeno-irradiation per alteraciones dysplastic in le scapos e atrophia del bulbos, e le numero de capillos afficite es proportional al dose de radiation. Esseva trovate que iste efecto es intensificate per le administration de colchicina, sed le synergismo esseva observate solmente quando le administration de colchicina precedeva le irradiation per dece-sex horas. Nulle altere del intervallos de tempore studiate permitteva le obtention de un simile efecto.

Esseva effectuate un essayo clinic del combinate efecto de roentgeno-irradiation e colchicina in un sol paciente con mycosis fungoide in qui le roentgeno-therapia per se habeva remanite inefficace. Como in le caso del experimentos animal, un bon responsa esseva observate quando le intervallo inter le administration de colchicina e le irradiation esseva dece-sex horas. Nulle alteration essential esseva apparente con intervallos de quatro e octo horas, sed un definite responsa esseva presente post intervallos de dece-duo horas.



WORK IN PROGRESS

The Design of Metallic Tip Catheters¹

ROBERT M. LOWMAN, M.D., and
COLIN M. BLOOR, M.D.²

Opacification of the aortic arch and, in particular, coronary arteriography have been carried out with various catheter designs (1, 2, 4, 7). Metallic tips have been used before but never described in detail (3, 5, 6). The development and plan of a new metallic catheter tip which permits the design and fabrication of catheters for differential opacification of the aortic arch comprises the basis for this report.

Catheter: A metallic tip (Fig. 1, A and B) is swaged to fit the end of a suitable piece of radiolucent polyethylene tubing. The design of this tip permits rapid construction of specific catheters when needed and it may be re-used. The metallic catheter tip has a smooth-bore polished surface. Two designs are available—one with an end opening and

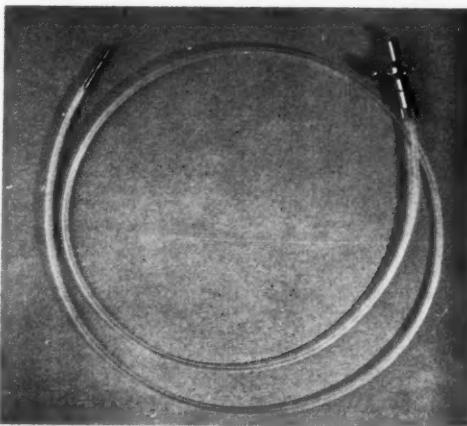


Fig. 1. A. Polyethylene catheter with closed-end, stainless monel metal tip in place.

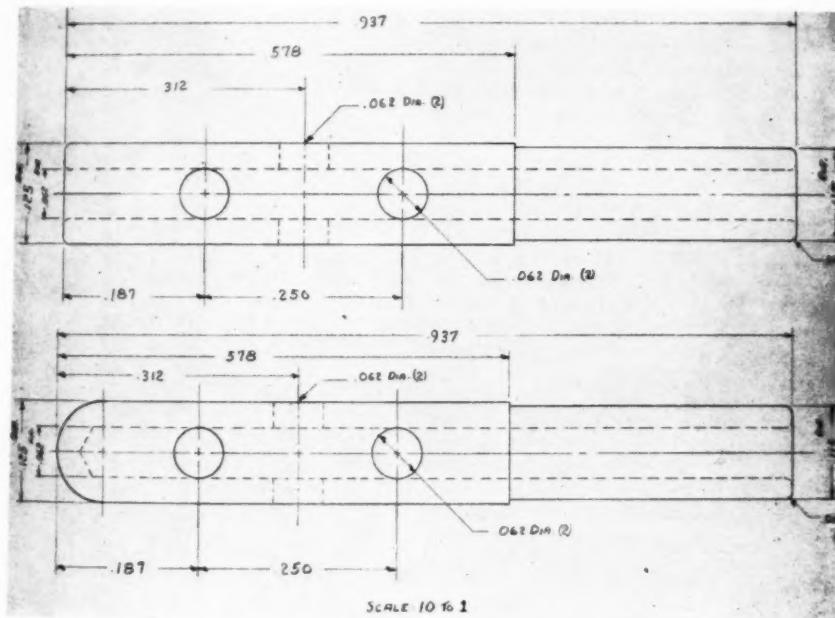


Fig. 1. B. Drawing of metallic tips, including dimensions to a scale of 10:1.

side holes and the other with a closed end and side holes.

Opaque guides (lead or stainless steel shots inserted into the distal tips) for polyethylene catheters of any size may also be used. These are heat-sealed in the ends of the catheter and can readily serve as markers.

Discussion: The metallic tip, when swaged to the end of a suitable polyethylene tubing, has produced catheters which could be localized with ease under fluoroscopic guidance. The design of the tip with its smooth-bore rounded surface provides for easy insertion into the arterial or venous channel. Catheters of this design can be utilized for retrograde

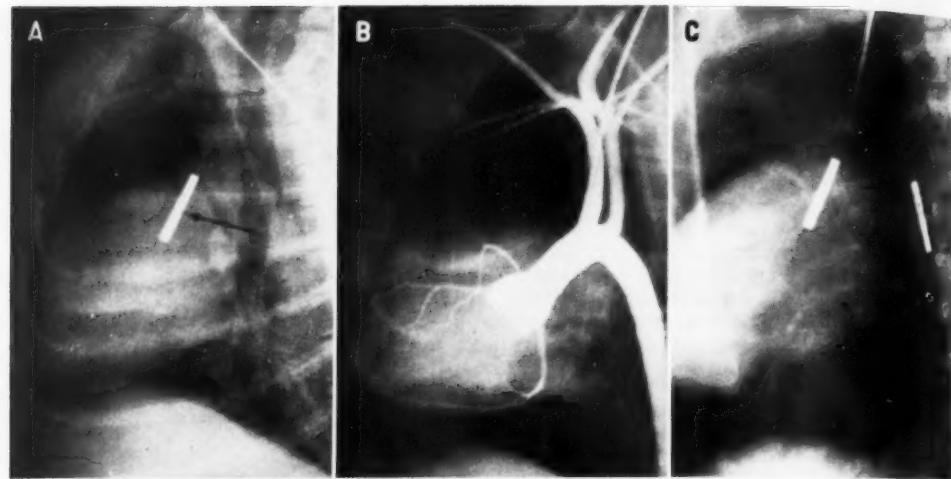


Fig. 2. Metallic tip catheter in use. A. The tip (arrow) serves as a marker locating the catheter's position in the supravalvular segment of the aorta. B. Closed-end metallic tip with side holes effectively sprays the opaque medium to opacify the supravalvular segment of the aortic arch. C. Metallic tip locates the catheter (arrow) in the descending aorta for regional pressure recording.

introduction into the arterial system without flexible wire guides.

The additional weight of the metallic tip aids in manipulation of the catheter with changes in the position of the animal. In addition, the tip obviates the need for injecting opaque material for localization of the catheter (Fig. 2, A). When the tip with a closed end and side holes is used, a spray-like effect of the medium is obtained. This can easily opacify the large volume of the supravalvular segment of the aortic arch (Fig. 2, B). The metallic tip also makes possible radiological localization of the catheter in specific regions of the vascular system for appropriate pressure recordings (Fig. 2, C).

Summary: The design of a new metallic catheter tip is described and illustrated.

The advantages of this metallic tip over other commonly used types in regard to ease of guidance and location are discussed. A tip of one design yields a spray-like effect of the opaque medium which renders opacification of large volumes, such as the supravalvular segment of the aorta, a standard procedure. The use of polyethylene tubing with the metallic tip provides a substantial reduction of cost in the fabrication of the catheters.

REFERENCES

1. BELLMAN, S., FRANK, H. A., LAMBERT, P. B., LITTMANN, D., AND WILLIAMS, J. A.: Coronary Arteriography. I. Differential Opacification of the Aortic Stream by Catheters of Special Design—Experimental Development. *New England J. Med.* **262**: 325-328, Feb. 18, 1960.
2. DOTTER, C. T., AND FRISCH, L. H.: Visualization of the Coronary Circulation by Occlusion Aortography: A Practical Method. *Radiology* **71**: 502-523, October 1958.
3. GIDLUND, Å.: Development of Apparatus and Methods for Roentgen Studies in Haemodynamics. *Acta radiol. Suppl.* **130**, 1956.

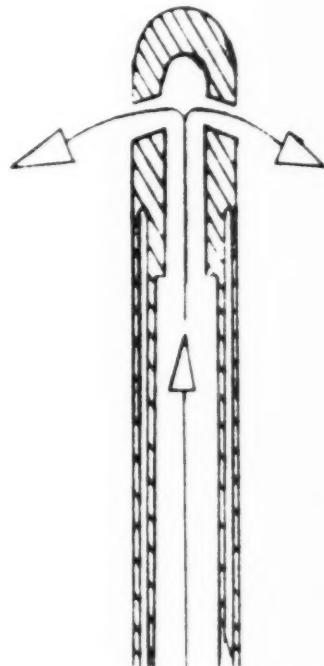


Fig. 3. Schematic diagram of closed-end metal tip with side holes, illustrating how the spray effect of the opaque material is achieved.

4. GOODALE, W. T., LUBIN, M., BANFIELD, W. G., JR., AND HACKEL, D. B.: Catheterization of the Coronary Sinus, Right Heart, and Other Viscera with a Modified Venous Catheter. *Science* **109**: 117-119, Feb. 4, 1949.

5. HETTLER, M.: Angiographische Probleme und Möglichkeiten. II. Der perkutane Arterienkatherismus mit an der Spitze verschlossenem Katheter als Grundlage der Etagen-Aortographie. *Fortschr. a.d. Geb. d. Röntgenstrahlen* **92**: 198-206, February 1960.

6. LINDELL, S. E., AND OLIN, T.: Catheterization of the Renal Arteries in Dogs and Cats. *Acta physiol. scandinav.* **39**: 73-82, April 10, 1957.

7. ÖDMAN, P.: The Radiopaque Polyethylene Catheter. *Acta radiol.* **52**: 52-64, July 1959.

¹ From the Departments of Radiology and Pathology of the Yale University School of Medicine, New Haven, Conn. Accepted for publication in April 1961.

This work has been supported by the U. S. Public Health Service Grant No. H 4834 C1.

² United States Public Health Service Trainee in Pathology.

EDITORIAL

Forty-Seventh Annual Meeting The Radiological Society of North America

The Forty-Seventh Annual Meeting of the Radiological Society of North America will be held November 26 to December 1, 1961, at the Palmer House, Chicago. We are especially fortunate this year in that the hotel has made available to us additional space on the fourth floor so that we will have three large meeting rooms close together for sections meeting simultaneously.

The Scientific Program for the meeting was arrived at by a process of selection that guarantees its excellence. The number of papers submitted far exceeded the time available and the Program Committee experienced great difficulty in making final choices among the many worthwhile contributions reviewed. It was with deep regret that we were obliged to reject many papers, and our sincere thanks are extended to the numerous applicants for whom room could not be made.

We are highly honored this year in having on the general program five outstanding Swedish radiologists, who will participate in the Diagnostic Sessions, the Therapy Sessions, and the Refresher Courses. Our Swedish guests are Dr. Elis Berven, Dr. Åke Lindbom, and Dr. Björn Nordenström of Stockholm, and Dr. Olle Olsson and Dr. Erik Boijesen of Lund.

The Refresher Courses will, as usual, be an outstanding feature of the meeting. Dr. Justin J. Stein will open the courses on Sunday afternoon with a symposium entitled, "Combined Radiotherapy-Chemotherapy in the Treatment of Cancer." The second session will be on the practical, photographic, mechanical, and electronic aspects of "Image Intensification and Cineradiography," presented by Drs. Majie Potsaid and E. W. Webster. Dr. H. M.

Stauffer has arranged a series of papers on the clinical aspects of this subject to be presented in the Diagnostic Section on Tuesday afternoon. The Sunday evening film-reading session will be conducted by Dr. Ted F. Leigh.

Refresher Courses will continue Monday morning from 8:30 to 12:00 followed by a group of Refresher Courses on each subsequent morning from 8:30 to 10:00. The list of courses, together with an application blank, will be published in the October issue of *RADIOLOGY*. Since the demand for many of these courses exceeds the room space available, it is advisable that application be made as early as possible. As in previous years, residents in radiology, trainees in physics, interns, and medical students will be exempt from paying the registration fee and will be accommodated in the three largest rooms—the Grand Ballroom, the State Room, and the Red Lacquer Room. If space is available at the beginning of a course held in a smaller room, they will be admitted.

A General Session of the Society is scheduled for Monday afternoon. Diagnostic Sessions will be held on Tuesday, Wednesday, and Thursday mornings and afternoons.

A Session on Radiobiology Tuesday morning has been arranged by Dr. G. M. McDonnel, and a Session on Nuclear Medicine Wednesday morning, conducted by Dr. John P. Storaasli.

The number of Therapy Sessions has been expanded this year because of the large number of excellent papers submitted in this field. Therapy Sessions will be held Tuesday afternoon, Wednesday afternoon, Thursday morning, and Thursday afternoon.

Physics Sessions, arranged by Dr. John Hale, will be held Thursday morning and Thursday afternoon.

Three Works-in-Progress Sessions are planned: Physics, Wednesday afternoon, under the direction of Dr. W. K. Sinclair; Diagnosis, Friday morning, conducted by Dr. Ted F. Leigh; Therapy, Friday morning, arranged by Dr. Jesshill Love.

The Memorial Fund Lecture will be given on Monday afternoon.

The Carman Lectures, which have been a tradition of the Society since 1934, came to an end at the 1960 meeting in Cincinnati. Beginning this year, these will be replaced by an *Annual Oration* honoring the memory of some eminent radiologist. The Annual Oration this year will be in honor of Dr. Donald S. Childs and will be given by Dr. Laurence L. Robbins on Tuesday evening.

A further innovation this year will be a dinner dance to be held on Thursday night, Nov. 30. The Gold Medal will be awarded immediately after the dinner.

As in previous years, the Commercial Exhibits Committee has arranged an excellent group of exhibits, though lack of space necessitated refusal of about thirty applications for this part of the program. It is hoped that the Palmer House will be able to enlarge the Commercial Exhibit space before another meeting.

Dr. Everett Pirkey has made all the arrangements for the Scientific Exhibits. Unfortunately, as with the Commercial Exhibits, space was not available to accommodate all the would-be exhibitors.

The Sales Department of the Palmer House has given invaluable assistance in arranging this meeting, and we take this opportunity to thank the staff for their many courtesies and suggestions in regard to innumerable details. The Society wishes, also, to express its sincere thanks to the Chicago Roentgen Society for offering to sponsor and aid the meetings of the Radiological Society of North America for the next five years in Chicago. Dr. George B. Cahill is General Chairman of the Local Committees, which have done an outstanding job to insure that our meeting will be a great success.

Mrs. George B. Cahill and Mrs. John H. Gilmore, Co-Chairmen of the Ladies Committee, have arranged an interesting series of events for the ladies. Beginning Monday, the Ladies Hospitality Room will be open every day, including Friday. Mrs. Cahill and Mrs. Gilmore urge that the attention of the ladies be called to the Hospitality Room as it affords an opportunity to meet old friends and make new ones.

Finally, as President, I wish to thank the speakers who are appearing on the program, the officers, the counselors, the committees (particularly the Program Committee), the many members whose aid we have enlisted, and Mrs. Marguerite Henry, for all their assistance in insuring an outstanding meeting of the Radiological Society of North America for 1961.

May I urge you all to come to Chicago and enjoy this meeting.

H. MILTON BERG, M.D.
President

RADIOLOGY REFRESHER COURSES: POSTGRADUATE INSTRUCTION SOUTHERN MEDICAL ASSOCIATION

As an experiment in postgraduate education, the Radiological Society of North America, in co-operation with the Southern Medical Association, will present four Refresher Courses during the annual meeting of the Southern Medical Association at the Adolphus Hotel in Dallas, Texas.

Attendance is limited to radiologists, including graduate students and residents in radiology, and medical students certified by the deans of their respective schools. Members of the Radiological Society of North America may attend the courses without charge. A registration fee of \$10 will be charged to other radiologists with the exception of graduate students and residents in radiology, members of the Armed Forces on temporary duty, and medical students certified by the deans of their respective medical schools. All must register at the Registration Desk. Payment of the registration fee by non-members is *not* to accompany the request for tickets but is to be paid at the time of registration. All Refresher Course tickets will be held at the Registration Desk in the Adolphus Hotel. Please call for them there. Positive identification will be

required for non-members and guests for admission to the Refresher Courses. If you cannot use the tickets you have reserved, please notify the Refresher Course Committee.

Admission to the Courses will be by presentation of the registration badge and a ticket for the desired Course. Read the description of the Courses, noting particularly the dates and time, and make your selection. Turn to the colored insert and indicate thereon those Courses which you wish to attend and mail the request promptly. The number attending the Courses will be limited by the capacity of the room, and request for tickets will be honored in the order in which they are received. You will be notified regarding the availability of tickets as soon as possible after receipt of your request.

We would appreciate suggestions concerning these Courses as they are presented, as well as your thoughts as to the desirability of this type of course at the Southern Medical Association. Please send any comments to the Chairman of the Refresher Courses Committee: John D. Reeves, M.D., University of Florida Hospital, Gainesville, Fla.

Course No. 1: Tuesday, November 7 1:30-3:00 P.M.

Some Fundamentals of Chest Roentgenology BENJAMIN FELSON, M.D., Cincinnati, Ohio

This course will deal primarily with principles rather than with specific disease entities. The material to be presented will be different from that of earlier refresher courses by the author. It will include the following:

1. The hila and pulmonary vasculature
2. The pleura
3. The diaphragm

Course No. 2: Tuesday, November 7 3:30-5:00 P.M.

Recent Advances in Gastrointestinal Radiology

RICHARD H. MARSHAK, M.D., New York, N. Y.

The course will be divided in four parts.

Part I: Newer concepts in the interpretation of lesions of the gastrointestinal tract.

Part II: Roentgen findings in the recently described syndromes such as the Zollinger-Ellison syndrome, Peutz-Jeghers' disease, carcinoid syndrome, toxic dilatation of the colon, villous adenoma, etc.

Part III: Technical factors in the examination of the gastrointestinal tract as well as a discussion of the various barium preparations.

Part IV: Questions and answers.

Course No. 3: Wednesday, November 8 1:30-3:00 P.M.

Recent Advances in Gastrointestinal Radiology

RICHARD H. MARSHAK, M.D., New York, N. Y.

(Continued from Tuesday, Course No. 2)

Course No. 4: Wednesday, November 8 3:30-5:00 P.M.

Roentgenography of the Plain Skull WILLIAM B. SEAMAN, M.D., New York, N. Y.

A review of the fundamental principles of the interpretation of the skull roentgenogram with particular emphasis on the evaluation of the sella turcica and the differential diagnosis of intracranial calcifications. The problem of the differential diagnosis of cranial hyperostoses will be presented and the differentiation of fibrous dysplasia and the hyperostoses associated with meningioma will be discussed in detail.

ANNOUNCEMENTS AND BOOK REVIEWS

ARKANSAS RADIOLOGICAL SOCIETY

Newly elected officers of the Arkansas Radiological Society are: President, Joseph A. Norton, M.D., Little Rock; Vice-President, Joe B. Scruggs, Jr., M.D., Little Rock; Secretary-Treasurer, Charles W. Anderson, M.D., 1108 1/2 Poplar, Pine Bluff; Councilor to the American College of Radiology, Joseph D. Calhoun, M.D., Little Rock; Alternate Councilor, Ernest A. Mendelsohn, M.D., Fort Smith.

NEW ENGLAND ROENTGEN RAY SOCIETY

Officers of the New England Roentgen Ray Society for 1961-62 are: President, John E. Gary, M.D., Lincoln, Mass.; President-Elect, Milford D. Schulz, M.D., Belmont, Mass.; Vice-President, Robert A. Grugan, M.D., Springfield, Mass.; Treasurer, H. Peter Mueller, M.D., Belmont, Mass.; Secretary, Robert E. Wise, M.D., 605 Commonwealth Ave., Boston 15, Mass.

The Society meets the third Friday of each month, October through April, at Longwood Towers, Brookline, Mass., at 4:30 P.M.

OREGON RADIOLOGICAL SOCIETY

The following are the new officers of the Oregon Radiological Society: President, L. Allan Gay, M.D., The Dalles; President-Elect, Joseph F. Haslinger, M.D., Portland; Secretary-Treasurer, George R. Satterwhite, M.D., Willamette Falls Community Hospital, Oregon City.

ANNUAL MEMORIAL MEDAL ASSOCIATION OF UNIVERSITY RADIOLOGISTS

The Association of University Radiologists has recently established an annual Memorial Medal Award in honor of deceased members, to be granted to the resident in radiology writing the best original paper on some aspect of radiology during the period of competition. The paper must be the work of a single author, the resident. Manuscripts to be considered for the 1962 competition must be received by March 1, 1962. Inquiries should be addressed and papers submitted to the Secretary, Herbert M. Stauffer, M.D., Department of Radiology, Temple University Medical Center, Philadelphia 40, Penna.

The 1961 Memorial Medal was awarded to Dr. Burton Seife, Resident, Yale University, for his paper, "Radioactive Inert Indicator Method for Intestinal Absorption Utilizing Differential Counting," presented at the recent meeting of the Association at Stanford University Medical Center, Palo Alto.

The 1962 annual meeting will be held at Indiana University, Indianapolis, May 19 and 20.

DR. RICHARD H. CHAMBERLAIN SUCCEEDS DR. EUGENE P. PENDERGRASS

Announcement has been made of the appointment of Dr. Richard H. Chamberlain, Professor of Radiology at the University of Pennsylvania School of Medicine, to the chairmanship of the Department of Radiology, succeeding Dr. Eugene P. Pendergrass. Dr. Pendergrass became emeritus professor of radiology on July 1, but continues in active medical practice.

Dr. Chamberlain is a native of Jacksonville, Fla. He was graduated from Centre College, Danville, Ky., in 1934 and received his M.D. degree from the University of Louisville School of Medicine in 1939. In 1946, he was appointed instructor in radiology at the School of Medicine of the University of Pennsylvania and in 1952 received advancement in academic rank to professor of radiology. He is a member of the Advisory Editorial Board of RADIOLGY.

Ceremonies honoring Dr. Pendergrass were held on July 24, in Medical Alumni Hall, Hospital of the University of Pennsylvania, when his portrait was presented to the University. Dr. Pendergrass has been associated with the University of Pennsylvania since his graduation from its School of Medicine in 1918. He served as Chief of Radiology in the Hospital and Chairman of the Radiology Department of the School of Medicine from 1937 until July 1, 1961. He is Past-President of the American College of Radiology and of the Radiological Society of North America. The portrait, painted by Roy F. Spreiter, a Philadelphia and New York artist, was presented by Dr. Philip J. Hodes, Chairman of the Department of Radiology at Jefferson Medical College, representing the Association of Pendergrass Fellows, an organization composed of former residents and fellows in radiology who received training in their specialty under Dr. Pendergrass.

OPERATIVE RADIUM THERAPY DAY QUEENS (N. Y.) HOSPITAL CENTER

An operative Radium Therapy Day is to be given at the Queens Hospital Center, Jamaica, N. Y., by the Radiation Medicine Department on Wednesday, Oct. 18, 1961. The program will cover the use of interstitial radiation in the oral cavity; radical insertion of radium in the neck; various applicators in carcinoma of the cervix; the Heyman applicators in carcinoma of the endometrium; radium needles in the parametria; and radon, iridium-thread, and cobalt interstitial therapy. Clinical demonstration will depend on availability of patients. Registration fee is \$10.00. Applications should be addressed to Dr. Philip J. Kahan, Supervising Medical

Superintendent, Queens Hospital Center, 82-68 164th St., Jamaica 32, N. Y.

ERRATUM

Due to an unfortunate typographical error in the article, "Chemical Protection Against X-Radiation in the Guinea-Pig," by Richard Wagner, M.D., and Irving B. Joffe, M.D., in *RADIOLOGY* for July 1961 (77: 125, 1961), the number of surviving animals was given as 2 instead of 8. The first sentence of the third paragraph from the end of the article should read: "The 8 survivors were re-irradiated with 275 r, and 6 of them were again protected with 100 mg. sodium ribonuclease before and after irradiation."

Letters to the Editor

THE SIGNIFICANCE OF GRID RATIO IN CLINICAL RADIOGRAPHY

Dr. Howard P. Doub, *Editor*

DEAR SIR:

In a paper on *The Significance of Grid Ratio in Clinical Radiography*, appearing in your esteemed journal in December 1960 (Vol. 75, pp. 925-931), Dr. Benjamin Felson and Mr. Otto E. W. Schmidt reported a comparative investigation with 8 different grids. All had the same lamellae density (strips/inch) and thickness, only the heights of the lamellae being different. The aim of the investigation was to demonstrate with the aid of *medical* objects that a higher grid ratio is better than a lower one.

In view of the fact that this investigation was conducted with the support of a prominent grid manufacturer, I think it worthwhile to make the following commentary.

As a rule, in practice—and for good reason in theory, too—grids with an equal number of lamellae per centimeter (should) have lamellae of greater thickness at a higher ratio. The thicknesses (should) change approximately proportionately with the height. The 8 grids with lamellae of different heights with equal thickness are therefore not representative of grids with different ratios as found in practice.

The investigation with these 8 grids can better be regarded as a particularly roundabout way (medical objects, 12 observers in three different cities) of confirming—with medical radiographs, too—the well known fact that more lead gives better contrast.

Since this can be proved much more exactly by other means, the results described, together with the conclusions, are rather to be seen as a proof that the *method* followed—along a difficult path—has nevertheless been reasonably good from the qualitative angle.

The danger of this publication is that it gives the impression that the ratio *as such*, i.e., independent

of other factors such as the number of strips per inch, is a factor of quality.

In the event that a material other than lead were used, e.g., uranium or tungsten, the article could lead to increased confusion, since better grids can then be produced with lower ratios.

Yours faithfully,
IR. W. HONDIUS BOLDINGH
Eindhoven, Holland

Dr. Howard P. Doub, *Editor*

DEAR SIR:

We are glad to have an opportunity to reply to Mr. Boldingh's criticism of our paper. His statement that grids with an equal number of lamellae per centimeter should have lamellae of greater thickness at a higher ratio is debatable and a matter of opinion. He further states that our 8 grids with lamellae of different heights, of equal thickness, are therefore not representative of grids with different ratios as found in practice. This statement is not true of grids used in the United States and we seriously doubt its validity with regard to European grids. The Liebel-Flarsheim Company, which manufactures most of the grids in the United States, uses the same lead thickness for all 80-line grids from 5:1 ratio up to 16:1 ratio, so our grids were certainly representative of those in this country. In a paper co-authored by Mr. Boldingh (*Acta radiol.* 52: 149, 1959) four of the grids described, despite the fact that they differed in ratio, had between 23 and 28 lines per centimeter and a lead thickness of 0.05 mm. Thus, Mr. Boldingh's statement in his letter is inconsistent with his earlier publication. We feel that the grids used in our investigation were quite representative of those employed in America, and probably also of those in Europe.

Mr. Boldingh mentions "the well known fact" that more lead gives better contrast. The "fact" quoted is one of the conclusions drawn in his 1959 article. In our opinion it is rather inconclusively supported by the evidence given. Independent investigation indicates that the relationship of both ratio and lead thickness to grid effectiveness is much more complex than he assumes. As far as our method being a "roundabout way," the proof of a grid's effectiveness is what it does for the radiologist under medical conditions. This seems to us to be the most direct approach possible to evaluate a grid for the man who is going to use it.

Our critic further states that "the danger of this publication is that it gives the impression that the ratio *as such* . . . is a factor of quality." The ratio definitely is a factor of quality. It is not the only factor determining the effectiveness of a grid but it is a very important one. Our paper also devotes several paragraphs to the various other factors involved. However, these were held constant in our study because grid ratio was the only variable under investigation.

In regard to the use of materials other than lead in the manufacture of grids, of course new standards and experimentation would then be required. Certainly, in this event, reliance should not be placed on any of the studies in the literature which utilize lead to remove secondary radiation.

Sincerely yours,

OTTO E. W. SCHMIDT
BENJAMIN FELSON, M.D.
CINCINNATI, OHIO

Books Received

Books received are acknowledged under this heading and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

Die JUVENILEN RÜCKGRATVERKRÜMMUNGEN. By Priv.-Doz. Dr. med. Friedrich Wilhelm Rathke, Heidelberg. With a Foreword by Prof. Dr. K. Lindemann, Heidelberg. A volume of 156 pages with 198 illustrations on 122 figures. Published by Georg Thieme, Herdwig 63, (14a) Stuttgart, Germany, 1961. Distributed in the United States and Canada by Intercontinental Medical Book Corporation, New York 16, N. Y. Price DM 23.60 (\$5.90).

La RADICULOGRAPHIE LOMBO-SACRÉE PAR SUBSTANCE IODÉE HYDROSOLUBLE ET RÉSORBABLE. By JACQUES FERRAND, Chirurgien des hôpitaux, JEAN ROBERT D'ESHOUGUES, Médecin des hôpitaux, Professeurs agrégés à la Faculté de Médecine, and JACQUES BARSOTTI, Chirurgien assistant des hôpitaux (Alger). With the technical collaboration of René Lamy, Électro-radiologue des hôpitaux d'Alger, and Robert Botella, Diplôme d'électro-radiologie. Preface by Prof. F. Coste. A monograph of 108 pages, with 82 figures. Published by Expansion scientifique française, 15, rue Saint-Benoit, Paris VI^e, France, 1961.

Book Reviews

CLINICAL USE OF RADIOISOTOPES: A MANUAL OF TECHNIQUE. Edited by THEODORE FIELDS, M.S., F.A.C.R. (Assoc.), Chief, Physics Section, Radioisotope Service, Veterans Administration Hospital, Hines, Ill.; Instructor in Radiology, Northwestern University Medical School; Attending Physicist, Cook County Hospital, Chicago, Ill.; Certified Medical Nuclear Physicist, American Board of Radiology, and LINDON SEED, M.D., Clinical Associate Professor of Surgery, University of Illinois College of Medicine; Director of Isotope Laboratories, Augustana Hospital, Chicago, Ill., and Oak Park Hospital, Oak Park, Ill.; Consultant in Radioisotopes, Veterans Administration Hospital, Hines, Ill. A volume of 476 pages, with 77 figures. Published by The Year Book

Publishers, Inc., Chicago 11, Ill., 2d ed., 1961. Price \$10.50.

Since the publication of the first edition of this book, the clinical application of radioactive isotopes has continued to expand. From the great number of variations of each basic procedure which have appeared, the editors of this volume have selected for discussion those which they consider to be most reliable. Their emphasis is upon possible differences of technic. Contributing authors were chosen for their particular interest and experience.

The contents are grouped in four parts covering routine clinical diagnostic tests, routine clinical therapy technics, planning and operating the radioisotope laboratory, and radiation safety. Not only are the recommended diagnostic and therapeutic technics described but there is some discussion of the selection of patients and the interpretation of results. Possible sources of error in performing the tests are described, and the value of the therapeutic procedures is considered.

The section on planning and operating a radioisotope laboratory includes a list of sources of radioisotopes and discusses their procurement from commercial and government suppliers. The section on Atomic Energy Commission regulations has been omitted from the second edition. Basic laboratory instrumentation and facilities, including radiation-measuring devices, are listed, and a suggested design for a laboratory is presented.

The section on radiation safety includes general recommendations for radiation safety and protection. Laboratory regulations are discussed, and protection of clinical and laboratory personnel is emphasized. Suggested instructions for handling radioisotope patients are presented in outline form. Appendixes include an extensive glossary, selected formulas, decay tables of some of the commonly used isotopes, and sample record and report sheets.

The procedures and technics selected for discussion seem sound and practical, and an extensive bibliography after each section permits reference to descriptions of other methods of performing the tests listed. While some may prefer particular technics not included here, the authors achieve their stated purpose of presenting a practical manual which should prove useful as a guide in setting up and operating a radioisotope laboratory.

INTRODUCTORY MANUAL ON THE CONTROL OF HEALTH HAZARDS FROM RADIOACTIVE MATERIALS. By the COMMITTEE ON PROTECTION AGAINST IONIZING RADIATIONS. Medical Research Council Memorandum No. 39. A pamphlet of 22 pages, with 7 tables. Published by Her Majesty's Stationery Office, London, England, 1961. Price 1s.9d.

The revised edition of this "Introductory Manual on the Control of Health Hazards from Radioactive

"Materials" is, like its predecessor, intended mainly for the guidance, in outline, of those concerned with the manipulation of radioactive materials in laboratories and elsewhere. The recommendations on maximum permissible doses of external and internal radiation and on maximum permissible concentrations of radioisotopes in air and in water are based on those of the International Commission on Radiological Protection (1959) and of its Committee on Permissible Dose for Internal Radiation (1960), as well as on those of the Medical Research Council's Committee on Protection Against Ionizing Radiations. Wherever there is lack of agreement between these two bodies, the British views, based on the most up-to-date information available, are expressed.

Brief but comprehensive directives are given under each of the chapter headings: General Nature of the Hazards; Maximum Permissible Dose of Radiation; The Measurement of Radiation Dose and Dose-Rate; Acceptable and Hazardous Amounts of Radioactive Material; Laboratory Facilities; Protective Clothing and Devices; Handling of Radioactive Isotopes; Eating, Smoking and Washing; Storage; Disposal of Radioactive Wastes (Liquid, Gaseous and Particulate, and Solid); Transport of Radioactive Material.

An appendix gives a table of shield thicknesses for laboratory sources.

LYMPHANGIOGRAPHIE UND LYMPHADENOGRAPHIE DER EXTREMITÄTEN. By Doz. Dr. FRITZ KAIDL, Dr. EVA MANNEHIMER, Dr. LILLY PFLEGER-SCHWARZ, and Doz. Dr. BRUNO THURNHER, Vienna. With a Foreword by Prof. Dr. K. Fellinger, Vienna. *Fortschr. a. d. Geb. d. Röntgenstrahlen, Ergänzungsband 87.* A volume of 72 pages, with 148 illustrations on 112 figures. Published by Georg Thieme, Herdweg 63, (14a) Stuttgart, Germany, 1960. Price DM 39.— (\$9.30); to subscribers to *Fortschritte*, DM 35.10. Distributed in the United States and Canada by Intercontinental Medical Book Corporation, New York 16, N. Y.

Twenty years ago the collagen diseases occupied the hinterland of clinical medicine. Then a few pioneering investigators opened the gate, particularly with the practical application of cortisone, permitting this group of diseases to enter into the

field of treatable ailments. Today medicine finds itself in a similar position as regards diseases of the lymphatic system. Here the gate that is opening is roentgen lymphangiography and lymphadenography; the key is the Kinmonth method of delineating and cannulating the lymph vessels. What the final revelations will be, one cannot predict; one can prophecy, however, an entire new sweep of diagnosis, prognosis, and therapy.

The authors of the present volume have concentrated on fundamentals, as is fitting with a new endeavor. Therefore, the most complete portion of the book deals with the normal anatomy—both microscopic and gross—of the lymph vessels as they appear on the roentgenogram. The two chapters on these aspects are preceded by a short historical survey and followed by minutely detailed directions for outlining the lymphatics with contrast material, cannulating the vessel, and producing workable roentgenograms. A very important phase of film interpretation, one usually neglected by theorists, is the detection of artefacts and false positives. Both are recognized by the authors, who assign them a full chapter.

On the basis of convenience, the lymphangiopathies are divided into two groups: the primary and the secondary. Developmental hypoplasia, lymphangiopathia obliterans, developmental lymphangiectasis, Milroy's disease, and certain of the lymphangitides are considered primary. Pressure obstruction, lymph cysts, varices of the lymphatics, post-phlebothrombosis syndrome, and obstruction from local trauma are classified as secondary.

This investigation is remarkable in that, as pointed out by Dr. K. Fellinger in the Foreword, it was conducted by free individuals, on a modest budget, without a houseful of expensive, special equipment. The volume is incomplete largely because it is a pioneering effort; any ideas for a complete definitive text must be postponed, perhaps for years. Lymphadenography in its normal and pathological phases is little more than glossed over here. The possible therapeutic application of Kinmonth's method of injecting a lymph vessel is not mentioned at all.

Nevertheless, despite its brevity, the book must be recommended because it is one of the first on the subject. It is adequately illustrated. The script is simple, precise German that augments the utility of this essay by keeping it unencumbered with verbiage.

medicine finds
seases of the
it is opening
lymphade-
method of
vessels
cannot pre-
entire new
y.

have concen-
with a new
portion of
tomy—both
vessels as

The two
by a short
ely detailed
ith contrast
producing
rtant phase
neglected by
s and false
the authors,

mphangiop-
the primary
hypoplasia,
entral lymph-
ain of the
Pressure
ympathics,
obstruction
ry.

as pointed
it was con-
est budget,
equipment.
use it is a
e definitive
ars. Lym-
phical phases
the possible
method of
at all.

book must
irst on the
The script
the utility
ered with

IN MEMORIAM

WILLIAM HENRY MEYER, M.D.
1879-1961

Dr. William H. Meyer of New York City, N. Y., died on June 14, 1961, of a ruptured abdominal aortic aneurysm.

Dr. Meyer was born on Dec. 17, 1879, in Brooklyn, N. Y., and received his medical education at the College of Physicians and Surgeons, Columbia University, obtaining his M.D. in 1902. Perhaps because of the promised certainty in diagnosis as a result of Roentgen's discovery in 1895, Dr. Meyer was attracted to radiology while still in college and, after a short time in general practice, began to specialize in that field, installing in his private office a machine which ran on static electricity. He acquired further experience in several city institutions and finally obtained an appointment as radiologist in Bellevue Hospital, and later at the New York Post-Graduate Hospital and Medical School. He was Director of Radiology at the latter institution from 1916 until his retirement in 1948.

Dr. Meyer was one of the pioneers in radiology, beginning in the early days when exposures were measured in fractions of an hour. At that time, his attention was focused on the osseous system. He was one of the first to emphasize the importance of right-angle projections for accuracy of interpretation. He also stressed the correlation of physics and mathematics with problems in diagnosis. This was the central theme of his textbook, *Clinical Roentgen Pathology of Thoracic Lesions*.

The Post-Graduate Hospital and the Hahnemann Hospital in Chicago had been the first in this country to install x-ray machines in 1896. Under Dr. Meyer's direction the first valve tube rectified x-ray diagnostic machine to be built in America was installed in the diagnostic division of the Post-Graduate Hospital, as was the first constant potential 200-kv deep-therapy transformer, the latter in 1921. Early in his directorship he was responsible for the development and installation of the first shock-proof deep-therapy tube shield.

Dr. Meyer was much concerned for accuracy of calibration in radiotherapy and collaborated with Otto Glasser in research to determine the variation in the erythema dose with quality. He followed up the work of the physicist, Christian, who stated, "Eventually all methods of quality determination will be evaluated by means of the half value layer."



William Henry Meyer, M.D.

Ten years after Dr. Meyer's first publication on the subject of the half-value layer the International Congress of Radiology accepted this as the preferred method of quality determination. In addition, he pioneered in depth-dose determination and time-dose relationship. He patented an x-ray penetrometer in 1921. He also developed a system of standardization for treatment in superficial cancer which was published in 1920.

Dr. Meyer became Professor of Radiology at the College of Physicians and Surgeons in the nineteen thirties and continued in that capacity until his retirement in 1948. He was a Fellow of the American College of Radiology and a member of the Radiological Society of North America. He was well known as an able and gifted teacher. He was a true physician, dedicated to scientific accuracy, and held in high respect for all his contributions and his day-to-day conduct of his professional duties in both therapy and diagnosis.

He is survived by his widow, the former Gertrude Steohr of New York.

SAMUEL L. BERANBAUM, M.D.

It is with deep regret that we report the death, on August 17, of Dr. Lawrence Reynolds, for many years editor of *The American Journal of Roentgenology, Radium Therapy and Nuclear Medicine*. Further notice will appear in a forthcoming issue of *RADIOLOGY*.

ABSTRACTS OF CURRENT LITERATURE

ROENTGEN DIAGNOSIS

The Head and Neck

KNUDSON, HARRIS W., AND FLAHERTY, ROBERT A.
Craniostostosis.....
BLATT, NICOLAS, ET AL. Alterations of the Optic Foramen in Crouzon's Disease (Craniofacial Dysostosis).....
LEGRE, J., ET AL. Cranial Lacunae Secondary to Traumatism in Early Childhood.....
GLASS, M. Fluid Levels Within the Paranasal Sinus Field: Their Nature, Character, Behaviour and Significance.....
LILIEQUIST, BENGT. Encephalographic Changes in the Axial Pressure Cone Syndrome.....
KÄGSTRÖM, ERIK, AND LINDGREN, PERCY. Changes in Intracranial Pressure During Carotid Angiography. An Experimental Investigation in Cats.....
DOBRAK, ALFRED H., ET AL. Cerebral Angiography in Patients over Fifty.....
RAYNOR, RICHARD B., AND ROSS, GERALD. Arteriography and Vasospasm. The Effects of Intracarotid Contrast Media on Vasospasm.....
CARMICHAEL, FRANCIS A., AND FORSYTH, ROBERT W. Roentgen-Ray Duplicating Head Rest for Pallidectomy.....

The Chest

DAVIS, LAWRENCE A. The Vertical Fissure Line. WULLSTEIN, H. L. Combined Fluoroscopy and Endoscopy of the Lower Respiratory Passages and the Oesophagus.....
CARDON, LEONARD. Significance of Small Pleural Effusions in Cardiopulmonary Disease, and Some Other Observations on Pleural Fluid in General.....
BATESON, ERIC M., AND ABBOTT, E. KATHLEEN. Mixed Tumors of the Lung, or Hamartochondromas. A Review of the Radiological Appearances of Cases Published in the Literature and a Report of Fifteen New Cases.....
LACKNER, J. Mediastinal Tumors During Childhood.....

The Heart and Blood Vessels

BARNHARD, HOWARD J., AND KNIKER, W. T. Roentgenologic Findings in Pertussis, with Particular Emphasis on the "Shaggy Heart" Sign.....
NORDENSTRÖM, BJÖRN, AND OVENFORS, CARL-OLOF. Septal Defect between the Left Ventricle and the Right Atrium Diagnosed by Cardioangiography.....
STOKES, JAMES M., ET AL. Coarctation of the Abdominal Aorta and Renal Artery Stenosis Corrected by Surgical Treatment: The Im-

portance of Individual Renal Function Tests in Selection of Proper Management.....

OPPENHEIMER, M. J., ET AL. Extravasation of Contrast Medium as Roentgen Criterion of Cardiac Necrosis in Dogs Following Intracoronary Injection of Urokon.....
MICHELL, GEORGE. Coronary Angiography.....
DAVIES, J. G., AND MICHELL, GEORGE. Timing of Injections for Angiocardiography: Description of an Automatic Device.....
SLOMAN, GRAEME, AND HARE, W. S. C. Clinical Application of Coronary Angiography.....
BASU, S. P., ET AL. Angiography in Leprosy.....
THURN, P., ET AL. Percutaneous Retrograde Thoracic Aortography and Levocardiography.....

The Digestive System

MORRIS, ROY. Dysphagia Lusoria Presenting as a Superior Mediastinal Syndrome.....
OSBORNE, G., ET AL. One Hundred Consecutive Cases of Dysphagia: Some Problems in Diagnosis.....
SOM, MAX L., ET AL. Narrow Esophagogastric Ring Treated Endoscopically.....
GINZBURG, LEON, ET AL. Regional Jejunitis.....
NICE, CHARLES M., JR. A Simple Experiment in Small-Bowel Motility.....
EDLING, N. P. G., AND EKLÖF, O. A Roentgenologic Study of the Course of Ulcerative Colitis.....
JAMIS-MUVIDI, ALBERTO. Giant Cyst of the Common Bile Duct. Preoperative Visualization by Transhepatic Cholangiography in 2 Cases.....
LEMPKE, ROBERT E. The Sphincter of Oddi and Gallbladder Function. I. Preservation of Function after Section and Resection of the Sphincter.....

The Musculoskeletal System

GIEDION, A. Soft-Tissue Changes and Radiological Early Diagnosis of Acute Osteomyelitis in Children.....
FIORE, JOHN M., AND SMYTH, WILLIAM T. Massive Osteolysis of Bone: Report of a Fatal Case with Temporary Reconstitution of the Affected Bone Following Irradiation.....
LINDBOM, Å., ET AL. Angiography in Osteoid Osteoma.....
WHITESIDES, THOMAS E., JR., AND ACKERMAN, LAUREN V. Desmoplastic Fibroma. A Report of Three Cases.....
HARDER, J. Osseous Lymphangiomyomatosis.....
SMITH, FRANK P., ET AL. Cinemyelography.....
CORDREY, LEE J., AND FERRER-TORELLS, MIGUEL. Management of Fractures of the Greater Multangular. Report of Five Cases.....

BOSWORTH, DAVID M., ET AL. Hip Shelves in Children.....	521	MENA, ISMAEL, ET AL. Analysis of Cardioportal Circulation Time by Means of Simultaneous Direct Hepatic Venous Counting.....	525	
BARRETT, A. F., AND VERNEY, G. I. Tomography and Other Radiological Methods in the Management of Congenital Dislocation of the Hip.....	521	COLLET, R. A. Application of Radioisotopes to the Study of Proteins.....	525	
JONASCH, E. Development of Osseous Changes Associated with Cysts of the Lateral Meniscus of the Knee.....	522	BULKLEY, GEORGE J., AND O'CONOR, VINCENT J. Carcinoma of the Prostate: Treatment by Interstitial Irradiation with Radioactive Gold—Experimental and Clinical Studies.....	526	
SEDLIN, ELIAS D. A Device for Stress Inversion or Eversion Roentgenograms of the Ankle.....	522	GOLDBERG, A., AND SEATON, D. A. The Diagnosis and Management of Myelofibrosis, Myelosclerosis and Chronic Myeloid Leukemia.....	526	
DOYLE, JAMES R. Narrowing of the Intervertebral-Disc Space in Children. Presumably an Infectious Lesion of the Disc.....	522	ZDANSKY, E. The Present Position of Telecobalt Therapy.....	526	
Gynecology and Obstetrics				
RIBEIRO, A. Observations on the Use of Aqueous Contrast Media in Hysterosalpingography.....	523	SARASIN, RAYMOND. Complications of Telecobalt Therapy.....	526	
HENRY, GEORGE W., AND HUNTER, ROBERT G. Hysterosalpingography with Water Soluble Medium (Salpix).....	523	FLETCHER, GILBERT H., ET AL. The Design of a Second Cobalt 60 Unit, Based on the Experience Acquired with 1,000 Patients Treated with the First Unit.....	526	
The Genitourinary System				
HODSON, C. J., AND EDWARDS, DAVID. Chronic Pyelonephritis and Vesico-ureteric Reflux.....	523	GUÉRIN, R.-A., AND GUÉRIN, MME. M.-T. Radioactive Strontium in Bone Disease.....	527	
WOODRUFF, MARVIN W., AND MALVIN, RICHARD L. Localization of Renal Contrast Media Excretion by Stop Flow Analysis.....	524	COSTE, F., ET AL. Osseous Fixation of Strontium and of Gallium: Clinical Applications.....	527	
The Spleen				
STEINBERG, ISRAEL, AND KARL, RICHARD C. Diagnosis of Rupture of the Spleen by Intravenous Abdominal Aortography. Report of a Case.....	524	GOTTSCHALK, RAYMOND G. Radioactive Sulphur in Chondrosarcomata. The Distribution, Concentration, and Effects of S ³⁵ After Intravenous Administration to Patients with Chondrosarcoma.....	527	
Miscellaneous				
HUKILL, PETER B., AND LOWMAN, ROBERT M. Visceral Metastasis from a Meningioma: Report of a Case.....	524	RADIATION EFFECTS		
RADIOTHERAPY				
TOMPKINS, M. G., ET AL. Carcinoma of the Endometrium.....	525	FRICK, HENRY CLAY, II., ET AL. A Study of Complications in the Surgical and Radiation Therapy of Cancer of the Cervix.....	528	
RADIOISOTOPES				
MARQUÈS, P., ET AL. Determination of the Cardiac Output by External Detection of Radioactivity of the Aortic Blood (Human Serum-Albumin Tagged with I ¹³¹).....	525	ABRAHAMSON, ROBERT HENRY. Radiation Ileitis.....	528	
COURT BROWN, W. M., ET AL. Incidence of Leukaemia After Exposure to Diagnostic Radiation in Utero.....				
POCHIN, E. ERIC. Leukemia Following Radio-iodine Treatment of Thyrotoxicosis.....				
LEWIS, T. L. T. Leukaemia in Childhood After Antenatal Exposure to X Rays: A Survey at Queen Charlotte's Hospital.....				
MCRAE, DONALD L. Diagnostic X-Ray Exposures: The Middle Road.....				
WALSH, ANTHONY. Hazards of Bladder Surgery Following Irradiation.....				
RÜBE, W., AND FLÖTE, F. Osteoradionecrosis of the Mandible.....				

ROENTGEN DIAGNOSIS

THE HEAD AND NECK

Craniosynostosis. Harris W. Knudson and Robert A. Flaherty. *Am. J. Roentgenol.* 84: 454-460, September 1960. (USAF Hospital, Lackland Air Force Base, Texas)

The roentgenograms of 36 patients with craniosynostosis, or premature closure of the cranial sutures, were reviewed to determine the reliability of the known roentgenographic signs of this condition and the diagnostic accuracy that can be expected.

Premature closure of the sutures of the skull may result in attenuation of the volume of the cranial vault, deformity of the cranium, and, occasionally, deformity of the face. The changes that occur depend upon the sutures involved and the time of closure. The rapidly growing infant brain normally stimulates the enclosing calvarium to enlarge in all directions. In craniosynostosis the ability of the skull to enlarge is partially restricted, to a greater or lesser extent. Little can be gained by operating on fused sutures at an age when brain growth has largely ceased. For optimal results in preventing mental retardation and severe deformity, early recognition and treatment are mandatory.

In the authors' group of 36 cases, there were 27 males and 9 females. A familial history of craniosynostosis was obtained in 3 patients. A high incidence of associated anomalies was noted. Two cases of syndactylism were encountered. Cephalohematoma was present in 4 patients and it may be that this association is related to the inability of the skull to mold normally at birth.

The roentgen appearance of the late changes of craniosynostosis—severe deformity, marked increase in digital markings, complete obliteration of suture lines and piling up of bone along the sutures—is quite characteristic. In early craniosynostosis the roentgen diagnosis is often difficult and must be based on less dramatic deformity of the calvarium and facial bones, bony bridging of the suture, narrowing or indistinct sutures and sclerotic margins along the sutures. Deformity of the calvarium is always present to some extent. Partial closure of a suture, even a segment a few millimeters long, has the same physiologic effect as complete fusion. The width of the suture line of and by itself is not a reliable sign because of the variation seen in normal infants. Bony sclerosis immediately adjacent to a narrowed suture may be suggestive of craniosynostosis but in the authors' experience proved unreliable.

The reliable and characteristic signs of craniosynostosis in the 36 cases are discussed by groups in the several clinical types: (1) sagittal suture closure, 22 cases; (2) unilateral coronal suture, 2 cases; (3) bilateral coronal suture, 1 case; (4) lambdoid suture, 2 cases; (5) metopic suture, 2 cases; (6) sagittal and unilateral coronal sutures, 2 cases; (7) sagittal and bilateral coronal suture closure, with or without involvement of other minor sutures, 5 cases.

The entire length of the suture must be excised regardless of the actual extent of the fusion. After three years of age there is only slight brain growth and any increase in head size is due largely to thickening of the calvarium and enlargement of the paranasal sinuses. Operation after this age offers little chance of improve-

ment; for the most favorable results surgery must be performed in the first few months of life.

Twelve roentgenograms.

NORMAN L. ARNETT, M.D.
Anaheim, Calif.

Alterations of the Optic Foramen in Crouzon's Disease (Craniofacial Dysostosis). Nicolas Blatt, D. Zamfir, M. Atanasiu, and H. Slobozianu. *J. de radiol.* 41: 645-659, November 1960. (In French) (Bucharest, Rumania)

In the pathology of the craniofacial dysostosis (Crouzon's disease, hypertelorism), the role of the optic foramen and its alterations is very important, because defects caused by the cranial malformations will determine the flattening and the strangulation of the foramen, leading to serious amblyopia or even to total blindness.

The authors present 4 cases of hypertelorism and deduct that atrophy of the optic nerve is closely related to alterations and deformations of the optic foramen, which follow the cranial malformations caused by the disease.

When the craniofacial dysostosis is associated with oxycephaly, the loss of vision can become very serious even if the optic foramen is not flattened to the maximum, because to the dystrophic obliteration of the foramen due to the disease is added an intracranial hypertension very often seen in oxycephaly.

Where the cranial sutures remain open the dystrophic process seems to be less intense, with little or no disturbance to the optic nerve and normal conservation of vision.

Fourteen roentgenograms; 3 photographs; 11 diagrams.

RENÉ HOURI, M.D.
New York, N. Y.

Cranial Lacunae Secondary to Traumatism in Early Childhood. J. Legré, D. Denizet, and J. Savelli. *J. de radiol.* 41: 667-678, November 1960. (In French) (Marseille, France)

Seven cases of cranial lacunae secondary to injury in early childhood are presented. In 5 cases the exciting cause was a fall; in 2 it was obstetric trauma during forceps delivery. All but 1 of the patients was referred because of epilepsy.

The authors describe the radiological characteristics and stress the importance of study of the borders of these defects. In the internal table, the borders are clean and rarely polycyclic, while the external table presents in general an important exophytic reaction with hyperostosis giving an appearance of eversion (*cimier de casque*).

Twenty-three roentgenograms; 1 chart.

RENÉ HOURI, M.D.
New York, N. Y.

Fluid Levels Within the Paranasal Sinus Field: Their Nature, Character, Behaviour and Significance. M. Glass. *M. Proc. (Johannesburg)* 6: 550-564, Nov. 19, 1960. (Cape Town, Union of South Africa)

At present the radiological recognition of free fluid within the paranasal sinuses is based upon an idealized sinus anatomy and the belief that all fluid levels are horizontal and remain so whichever way the head is tilted in the erect position. The author calls attention

to the fact that sinal fields are morphologically unpredictable and pathologically variable, and intrasinal space not a fixed, uniform, immutable entity.

The various suggestions advanced from time to time for the recognition of free fluid in the paranasal sinus fields are considered, and their fallacies and inadequacies pointed out. The author's studies show that (1) not all sinal fluid levels are horizontal, nor is horizontality always reproducible on tilting; (2) a nonentesimal cyst (a nonfree element) can present a horizontal upper limit which the customary partial tilt test can reproduce; (3) it is not possible to limit the behavior of a truly "free" fluid to the reproduction and visible demonstration of horizontality within unpredictable and variable sinal space. The free fluid may disappear behind swollen mucosa, polyp or neoplasm, or into or behind a pathologically involved "supernumerary" sinus or compartment, here to disgrace itself still further by forming a nonhorizontal fluid level. Since free fluids collect, pool, and form liquid levels in air cells of differing development, numbers, arrangement, relationship, intercommunication, and pathology, fluid levels in the sinuses can vary not only in character, but also in extent, number, position, arrangement, and relationship. Anatomy, pathology, and physical laws determine the patterns and significance of the behavior of free fluid within the sinal fields. All sinal fluid levels are concave, with the degree of concavity an inverse function of the degree of separation between the limiting surfaces of the zones of pooling and collection with an unpredictable and variable sinal field. On the roentgenogram, a wave-like pattern betokens subdivided space, as within a multicelled frontal sinus. If no communication exists, there may be numerous small fluid levels of different heights.

The author concludes that presently held diagnostic concepts are unequal to their interpretive responsibilities and should be discarded.

Thirty-eight roentgenograms, with accompanying drawings. ANDREW K. POZNANSKI, M.D. The Henry Ford Hospital

Encephalographic Changes in the Axial Pressure Cone Syndrome. Bengt Liliequist. *Acta radiol.* 54: 369-378, November 1960. (Serafimerlasarettet, Stockholm, Sweden)

In 14 patients examined with lumbar encephalography at Serafimerlasarettet (Stockholm), air did not pass up through the aqueduct, although the fourth ventricle was air-filled. Subsequently, in all cases, a supratentorial expansive process was demonstrated by either ventriculography or carotid angiography. The presence of a tumor was verified in all cases, either at operation or postmortem. In 10 cases the expansive process was situated in the frontal lobe; in 2 cases the tumor lay in the temporal lobe and middle fossa, respectively, and in 1 case in the parietal lobe; in another it had a parasagittal frontoparietal location. In addition, 70 cases of frontal tumor examined by lumbar encephalography were re-examined with special reference to the shape of the brain stem, the relationship between the aqueduct and the fourth ventricle, and the deformation of the third ventricle.

In all the 14 cases in which the air did not pass up through the aqueduct, the brain stem had been compressed from side to side and had acquired a more or less distinct pear-shape. This may lead to partial or complete obstruction of the aqueduct. Such changes

are seen most frequently with frontal expansive processes but may also occur with temporal and parietal tumors. Similar though not so marked changes are often observed in the incisura tentorii in the presence of frontal tumors, without however, leading to a complete obstruction of the aqueduct.

An obstruction of the aqueduct caused by herniation due to a supratentorial expansive process may be differentiated from stenosis of the aqueduct by the fact that it has a different site. Also, the cisterns around the brain stem are as a rule widened in stenosis of the aqueduct, even if a downward displacement of cerebral parts through the incisura tentorii is noted. When, on the other hand, the kink in the aqueduct is due to an expansive process in the posterior fossa, the pontine cistern and the pontocerebellar cisterns are always changed, and the tonsils are herniated through the foramen magnum. This is not the case when the change in the aqueduct is produced by a supratentorial expansive process. A herniation into the incisura tentorii of the type described leads to an incomplete or complete obstruction of the aqueduct and the posterior part of the third ventricle by compression and deformation of the surrounding cerebral regions. The anterior portion of the third ventricle will consequently become widened and its recesses will bulge into the interpeduncular cistern.

Six roentgenograms.

JULIAN O. SALIK, M.D.
Baltimore, Md.

Changes in Intracranial Pressure During Carotid Angiography. An Experimental Investigation in Cats. Erik Kågström and Percy Lindgren. *Acta radiol.* 54: 379-392, November 1960. (Karolinska Institutet, Stockholm, Sweden)

The intracranial pressure was recorded in cats following an injection of sodium acetrizoate and sodium diatrizoate into the common carotid artery. A temporary elevation of the intracranial pressure, probably due to cerebral vasodilatation, followed the injection of sodium acetrizoate; corresponding amounts of sodium diatrizoate produced little or no change.

In the authors' view the results of this investigation demonstrate, at all events, the advantages of avoiding the use of contrast media with a high vascular activity for cerebral angiography in human beings.

Seven illustrations. THEODORE E. KEATS, M.D.
University of Missouri

Cerebral Angiography in Patients Over Fifty. Alfred H. Dobrak, Arthur L. Beck, Jr., Thomas J. Murphy, and John G. Zoll. *Arch. Neurol.* 3: 582-588, November 1960. (1275 Delaware Ave., Buffalo 9, N.Y.)

The authors discuss the contribution of cerebral angiography in the diagnostic work-up of 38 patients, over the age of fifty, who were believed to be suffering from a cerebrovascular catastrophe. Routinely, the angiographic examination consisted of 12 or more roentgenograms; 3-phase filling of the common carotid and one vertebral artery was demonstrated in lateral views and arterial filling in occipital projections. Other views in various phases of filling were taken as indicated. Since 1957, the contrast medium employed has been 50 per cent sodium diatrizoate (Hypaque); the average amount used was about 35 c.c., with individual injections of 5 to 8 c.c. No anaphylactic reactions were encountered. Cardiac arrest occurred during the initial phase of the procedure in 1 patient, who recovered

following thoracotomy with restoration of normal cardiac rhythm.

Of the 38 cerebral angiographic examinations, 15 showed a definite abnormality and 3 a questionable abnormality. There were 16 deaths. No one likes to conclude that the diagnostic procedure influences the mortality rate in a highly fatal condition such as cerebrovascular disease. That it is a contributing factor, however, must be entertained. Four of the deaths in the present series were believed to be due in part to the study, but it is thought that the other 12 deaths were not influenced by angiography.

Eight cases are reported.

Seven roentgenograms; 3 tables.

GORDON L. BARTEK, M.D.
Grand Rapids, Mich.

Arteriography and Vasospasm. The Effects of Intracarotid Contrast Media on Vasospasm. Richard B. Raynor and Gerald Ross. *J. Neurosurg.* **17**: 1055-1061, November 1960. (Neurological Institute of Columbia-Presbyterian Medical Center, New York, N.Y.)

When patients have a pre-existing cerebral vascular disease or a neurological deficit, there appears to be an increased incidence of complications from cerebral angiography (Pendergrass *et al.*: *Am. J. Roentgenol.* **48**: 741, 1942. *Abst. in Radiology* **41**: 98, 1943). One explanation for this is that most contrast media are allergens and can produce reactions of hypersensitivity; another is that the contrast medium itself may be cytotoxic. A more likely cause of complications in cerebral angiography may be vasospasm.

The authors carried out experiments in cats to determine the influence of diatrizoate sodium (Hypaque) on the spasticity of a previously irritated cerebral vasculature. The internal carotid artery distal to the cavernous sinus and the middle cerebral artery and its branches were exposed; the artery was then stroked with a blunt nerve hook twenty times for a distance of about 1 cm. Serial photographs were then taken. The vessels examined contracted 25 to 33 per cent in diameter; the average duration of spasm was four minutes. Eighteen to twenty-five minutes later the artery was restroked; immediately thereafter 3 c.c. of Hypaque was injected in 8 cats. The average duration of the spasm was prolonged to seven minutes, but the degree of contraction did not differ from that seen on the initial stroking. Another eighteen to twenty-five minutes were allowed to elapse, and the artery was then subjected to a third period of stroking. This resulted in the same degree of spasm, but lasting on the average only two and three-fourths minutes.

In 3 cats the above procedure was performed but isotonic saline was used for the injection instead of Hypaque; in all 3 the duration of the spasm following the stroking and injection of saline was less than that following the initial stroking.

In 3 other animals the vessel was stroked and allowed to return to its original size. Hypaque was then injected without any additional stroking, and in no instance was spasm produced.

The experimental evidence seems to indicate that the intracarotid injection of Hypaque into an already irritable vessel will double the duration of the spasm. When the medium is injected into a normal vessel, no spasm is produced. It seems reasonable to assume that the cerebral vessels may be more irritable in the

region of subarachnoid hemorrhage, ruptured aneurysm, or tumor. The injection of contrast medium during angiography may cause enough additional interference to an already compromised circulation to result in clinical symptoms.

Three illustrations; 3 tables.

SAMUEL B. HAVESEN, M.D.
Lynwood, Calif.

Roentgen-Ray Duplicating Head Rest for Pallidotomy. Francis A. Carmichael and Robert W. Forsyth. *J. Neurosurg.* **17**: 1116-1118, November 1960. (411 Nichols Road, Kansas City 12, Mo.)

Certain intracranial procedures, most notably pallidotomy, have often proved haphazard because of the inability of the operator to be assured of successively identically oriented roentgenograms. The errors which contribute the most to this anatomical confusion are: (1) variation in the position of the head between exposures; (2) alteration in the position of the cassette in relation to the head; (3) variability in the position of the x-ray tube in relation to the head.

The authors describe a head rest which was designed in the hope of reducing these errors. The apparatus is relatively small and light in weight, being made of aluminum. It is designed to fit presently available equipment, namely, the American Sterilizer Series #1090 operating tables. The principle of the head rest is to secure in a never varying relationship (1) the cassette, (2) the patient's head, and (3) the x-ray beam. This is accomplished by having the head rest and cassette holders fabricated in one rigid frame. The head is secured by either 3- or 4-point bony fixation. The drill points may be pre-set to any depth of penetration from 0 to 1/4 inch. Exact duplication of the position of the tube and its incident beam of x-rays is assured by the use of optical range finding.

Four roentgenograms.

SAMUEL B. HAVESEN, M.D.
Lynwood, Calif.

THE CHEST

The Vertical Fissure Line. Lawrence A. Davis. *Am. J. Roentgenol.* **84**: 451-453, September 1960. (226 E. Chestnut St., Louisville 2, Ky.)

In general, the major interlobar fissures are visualized roentgenographically only in the lateral projection, while the minor fissure is seen in both lateral and frontal views. That the major fissures are not always precisely in the coronal plane has been demonstrated by the fact that slight rotation occasionally brings out a fissure not visible in the true lateral projection.

In infants and children, a vertical fissure line has been noted paralleling the right thoracic wall and ending in the vicinity of the minor fissure. These fissures have been seen in patients with normal hearts but, more frequently, in those with enlarged hearts. In the author's series of 29 patients with a demonstrable vertical fissure line, 19 had evidence of cardiomegaly. Fluid may accumulate in this fissural space, as in any other pleural space, and pulmonary infiltrates can be limited by this septum.

This vertical fissure line is, according to the author's studies, the lateral portion of the major fissure which has been directed in an anterior position so that this portion is in a sagittal plane and thus is visualized on the frontal roentgenogram. The mechanism would

seem to be explained in those patients with enlarged hearts by the rotation of the fissure as the mediastinum enlarges.

The major fissure actually consists of two segments divided by the insertion of the minor fissure. With cardiac enlargement the lower lobe appears to pivot on its hilar attachments in relation to the fixed middle and upper lobes. Thus, the upper portion of the vertical fissure line ends in the minor fissure. The portion of the upper lobe lateral to the vertical fissure is thin. An apparent lack of vascular markings has caused a misdiagnosis of localized pneumothorax. In 1 patient, because of this mistake, pleural aspiration was attempted; a large tension pneumothorax developed subsequently, which required an open thoracostomy tube for decompression.

Six roentgenograms; 1 diagram.

NORMAN L. ARNETT, M.D.
Anaheim, Calif.

Combined Fluoroscopy and Endoscopy of the Lower Respiratory Passages and the Oesophagus. H. L. Wullstein. *German M. Monthly* 5: 338-339, October 1960. (Universitäts-Hals-Nasen-Ohrenklinik, Würzburg, Germany)

The author has designed a table which, in conjunction with an image-amplifier system, has been employed for combined fluoroscopy and endoscopy. The table is supported by a single lateral column and can be raised or lowered electrically. The head can be lowered to 15° from the horizontal. Lateral rotation around the longitudinal axis of the body is achieved manually. Fluoroscopy can be carried out in any desired position. The position of the television screen and intensifier can be easily adjusted to the position of the patient and is quite independent of the endoscopy table. During use of the television monitor, total darkness is unnecessary and not even desirable; the degree of room darkening and adaptation required for endoscopy is also appropriate for observation of the monitor. This equipment has been found to be particularly useful in direct endoscopic examinations and in contrast filling of selective lung segments.

One roentgenogram; 2 photographs.

JOHN P. FOTOPoulos, M.D.
Northwestern University Medical School

Significance of Small Pleural Effusions in Cardio-pulmonary Disease, and Some Other Observations on Pleural Fluid in General. Leonard Cardon. *Ann. Int. Med.* 53: 765-795, October 1960. (185 N. Wabash Ave., Chicago 1, Ill.)

A massive pleural effusion of the common idiopathic type may be well tolerated by a young adult with a normal heart and a normal contralateral lung. A relatively small pleural effusion, however, may precipitate a critical degree of dyspnea and air hunger, and even cause death, in the presence of antecedent cardiac and pulmonary disease which already seriously interferes with pulmonary function and causes difficulty in breathing. As little as 500 ml. may be of significance in this regard. This situation occurs most commonly in middle-aged or elderly persons with coexistent congestive heart failure and pulmonary emphysema or fibrosis.

Diagnosis of a small effusion in the presence of heart failure and emphysema may be difficult. The amount of fluid corresponding to a given vertical height of percussion dullness in the patient with an emphysematous

chest is frequently underestimated. Impairment of resonance due to fluid may be masked or its extent diminished by the hyperresonance of the associated emphysema. The same volume of fluid will rise to a much higher vertical level in the normal flat, narrow chest than in the broad barrel chest of the patient with chronic pulmonary emphysema, in which the fluid spreads out and lies in a much thinner layer over the larger basal (diaphragmatic) area of the pleural cavity. Because of the flattening and depression of the diaphragm in the emphysematous chest, the base on which the fluid rests is lower than in the normal chest, and the upper extent of dullness is therefore lower. Bronchial breath sounds, rather than diminished or absent breath sounds, may be heard over a small collection of fluid and be misinterpreted as consolidation of the lung. Under these conditions, the diagnosis is based mainly on a high index of suspicion that *any degree and extent of impairment of resonance*, particularly over the dependent portions of the chest posteriorly, may be due to pleural fluid, and the free use of exploratory puncture, properly performed, to test this suspicion.

Unfortunately, the chest roentgenogram cannot be relied upon as the final arbiter. The patient may be too dyspneic and restless to cooperate, or oxygen cannot be discontinued for the time required to take the films. Roentgenograms taken with a portable machine may be unsatisfactory. Amounts of fluid as small as those under consideration may not be recognizable. The fluid may lie in bizarre pockets along the course of the fissures. Or it may be hidden behind the heart or posteriorly below the bulge of the diaphragm.

Patients with refractory heart failure and digitalis intoxication due to overmedication often have unrecognized pleural effusions. The patient with acute pulmonary edema who does not respond to treatment should be carefully examined for evidence of hydrothorax; mechanical removal of pleural fluid, when present, may be the only means of permanently relieving the edema. Early thoracentesis is indicated when any degree of hydrothorax in cardiac failure is associated with a significant degree of dyspnea.

Twenty-seven illustrative cases are reported.

Nine roentgenograms; 3 diagrams.

PAUL F. CHRISTENSON, M.D.
Fontana, Calif.

Mixed Tumors of the Lung, or Hamarto-chondromas. A Review of the Radiological Appearances of Cases Published in the Literature and a Report of Fifteen New Cases. Eric M. Bateson and E. Kathleen Abbott. *Clin. Radiol. (J. Fac. Radiologists)* 11: 232-247, October 1960. (The General Hospital, Nottingham, England)

The authors review the literature on the comparatively rare tumor, the hamarto-chondroma, as found in the lungs, and record 15 new cases. After analyzing the radiological appearance of over 200 of these tumors (226 intrapulmonary; 27 endobronchial), the following conclusions are reached:

1. It is impossible to diagnose or even suspect the presence of an endobronchial hamarto-chondroma on the basis of radiological investigations.

2. Large intrapulmonary masses with a lobulated outline and containing irregular areas of calcification will almost certainly prove to be hamarto-chondromas.

3. Small intrapulmonary lesions exhibiting a well defined, lobulated outline, with no calcification and no

satellite shadows, have a strong possibility of being hamartochondromas, and a large proportion of these tumors present this appearance.

4. Small shadows containing calcification are more likely to represent tuberculomas than hamartochondromas, but the latter diagnosis should be considered, particularly if the other features of tuberculous lesions are absent.

5. Small round or oval lesions without lobulation or large masses which may or may not be lobulated may be hamartochondromas, but if calcification is absent this is an unlikely diagnosis and should only be considered as a remote possibility.

The range and methods of radiologic diagnosis are given and the value of tomography is stressed.

Eighteen roentgenograms; 1 photograph; 1 photomicrograph; 7 tables. THEODORE E. KEATS, M.D.
University of Missouri

Mediastinal Tumors During Childhood. J. Lackner. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 93: 429-444, October 1960. (In German) (Städtische Krankenanstalten Bremen, Germany)

Eighteen cases of mediastinal masses in children are evaluated with reference to diagnosis. Fourteen were surgically verified: 7 neurogenic tumors including 4 sympatheticoblastomas, 1 malignant gangliocytoma and 2 ganglioneuromas; 2 enterogenous cysts; 1 paratracheal cyst; 2 thymic tumors—a carcinoma and a cystic teratoma; 1 teratoma; 1 case which proved to be chronic pneumonia with abscess formation. The 4 remaining cases were diagnosed clinically as 1 of lymphosarcoma, 2 of leukemia, and 1 of an atypical consolidation which cleared up after an attack of measles.

In the diagnosis of mediastinal tumors, roentgen studies play a predominant role. A survey includes fluoroscopy, routine and lateral views of the chest, barium filling of the esophagus, and tomography in two planes. Tumors of the thyroid and thymic gland, teratoma, and pericardial cysts are usually located in the upper anterior and middle mediastinum. Cystic lesions are found in the middle mediastinum, and neurogenic tumors in the posterior mediastinum.

Roentgenologic studies are most helpful in differentiation between benign and malignant lesions. Radiotherapeutic tests have been replaced in recent years by surgical exploration. The latter has become less hazardous with improved technics and permits establishment of the correct diagnosis.

Fourteen cases are illustrated and briefly commented upon.

Twenty-two roentgenograms; 1 drawing.

ERNEST KRAFT, M.D.
Northport, N. Y.

THE HEART AND BLOOD VESSELS

Roentgenologic Findings in Pertussis, with Particular Emphasis on the "Shaggy Heart" Sign. Howard J. Barnhard and W. T. Kniker. *Am. J. Roentgenol.* 84: 445-450, September 1960. (University of Arkansas Medical Center, Little Rock, Ark.)

Recently the authors have been struck by the frequency with which a rather distinctive roentgenologic chest pattern has been seen in cases of pertussis. This pattern basically consists of dense markings which fan out around the heart border and so obscure it that this has been called the "shaggy heart" sign. The records

and roentgenograms of all children with pertussis admitted to the University of Arkansas Medical Center Hospital between July 1955 and June 1959 were reviewed in an attempt to determine if the roentgen findings will permit a diagnosis of pertussis with some degree of accuracy.

Of the 32 cases of pertussis found, 13 displayed the "shaggy heart" sign. The shagginess may end abruptly just beyond the heart or it may blend partially with densities occupying more peripheral areas. The mildest form, or perhaps actually a regressing phase, usually obscures only a part of the cardiac silhouette. The "shaggy heart" pattern characteristically begins in the paroxysmal stage and tends to extend into the resolution period. In 1 patient, however, it was present for ten weeks beyond the paroxysmal phase; frequently it is demonstrable during only part of the paroxysmal period. No correlation could be found between the presence of the "shaggy heart" sign and sex, season, or area of the state. There seemed to be a tendency for the "shaggy heart" to be associated with the more severe and prolonged illness.

The exact pathophysiologic basis for the "shaggy heart" sign is unknown. One of the possibilities mentioned is the plugging of the bronchi by viscid mucus.

The authors conclude that while the "shaggy heart" sign is not pathognomonic of pertussis, it should strongly suggest the diagnosis. Other entities to be considered in the differential diagnosis are the aspiration pneumonias, particularly those associated with hydrocarbons, interstitial or bronchopneumonia, and cystic fibrosis of the pancreas.

Four roentgenograms; 2 charts.

NORMAN L. ARNETT, M.D.
Anaheim, Calif.

Septal Defect between the Left Ventricle and the Right Atrium Diagnosed by Cardioangiography. Björn Nordenström and Carl-Olof Övenfors. *Acta radiol.* 54: 393-396, November 1960. (Karolinska Sjukhuset, Stockholm, Sweden)

The authors report what is believed to be the first case of septal defect between the left ventricle and the right atrium to be diagnosed preoperatively. The defect is situated within the small area where the left ventricle and right atrium have a common wall, that is, just cranial to the septal leaflet of the tricuspid valve in the floor of the right atrium.

The patient was a 22-year-old woman with a heart murmur but no cardiac symptoms since childhood. The right atrium was chiefly enlarged, but the right ventricle and left atrium were also affected. The central and peripheral branches of the pulmonary artery were considerably dilated while the aorta was of about normal width, with perhaps some narrowing of the arch. With the exception of the right atrial dilatation, the evidence suggested a ventricular septal defect. On heart catheterization normal pressures were found in the right atrium, ventricle, and pulmonary artery. Blood gas analyses showed that arterial blood admixture occurred in the right atrium. Cardioangiography was performed with the injection of contrast medium into the left ventricle after transthoracic ventricular puncture. This revealed a high ventricular defect, measuring about 10 mm., in a craniocaudal direction. The contrast medium passed through the defect directly to the considerably enlarged right atrium before the right ventricle was filled. The findings were confirmed at

pertussis
al Center
were re-
roentgen
with some

played the
abruptly
with den-
the mildest
, usually it is
te. The
ns in the
resolution
t for ten
tly it is
oxymal
een the
ason, or
ency for
ne more

"shaggy
es men-
tus.
" heart"
should
s to be
aspira-
d with
ia, and

M.D.
Calif.

and the
Björn
ol. 34:
hachuset,

the first
and the
The
the left
, that
valve

heart
hood.
right
the cen-
artery
about
arch.
, the
On
d in
artery.
ture
was
into
un-
sur-
The
y to
ight
at

operation; there was also, however, a small defect in the septal leaflet of the tricuspid valve.

Four roentgenograms.

THEODORE E. KEATS, M.D.
University of Missouri

Coarctation of the Abdominal Aorta and Renal Artery Stenosis Corrected by Surgical Treatment: The Importance of Individual Renal Function Tests in Selection of Proper Management. James M. Stokes, Hulda Wohltmann, and Eric Carlson. *Ann. Surg.* 152: 856-860, November 1960. (Washington University School of Medicine, St. Louis, Mo.)

The authors report a case of coarctation of the abdominal aorta in a twelve-year-old girl with malignant hypertension. Initial examination revealed a blood pressure of 220/160 mm. Hg in both the upper and lower extremities. Intravenous pyelography showed a normal renal excretory system, and retroperitoneal air studies failed to demonstrate a tumor. The hypertension was very difficult to control with drugs. The pre-operative presumptive diagnosis entertained was pheochromocytoma by virtue of the response to Regitine and the lack of evidence for other causes of hypertension. At operation, the adrenals were found to be normal and contained no tumors.

Retrograde aortography through the femoral artery was then performed. The roentgenograms were interpreted as showing a coarctation of the abdominal aorta below the superior mesenteric artery and an ostial stenosis with a post-stenotic dilatation of the left renal artery. A second operation disclosed that below the enlarged superior mesenteric artery the aorta became con shaped. The renal arteries arose from a narrowed portion, and the aorta was a solid cord-like structure without pulsation distal to the renal arteries. The pulse in the left renal artery was small and a thrill was felt at its origin from the aorta. One iliac limb and the aortic segment of a lyophilized aortic bifurcation homograft were used to establish a shunt from the thoracic aorta to the abdominal aorta distal to the coarctation. The other iliac limb of the bifurcation homograft was anastomosed end-to-side to the left renal artery distal to the stenosis.

Postoperatively, the pulses in the lower extremity were much stronger and the blood pressure in the lower extremities was 30 to 40 mm. Hg higher than it was preoperatively. The child was discharged from the hospital on antihypertensive drug therapy. Intravenous urography on two occasions during the next four months showed the left nephrogram to be consistently less radiopaque than the right. This was erroneously thought to represent relatively poor excretory function by the left kidney. More definitive renal function tests were then performed and these disclosed that the *right kidney, not the left, functioned poorly*. On this basis, a knitted Dacron graft was placed between the abdominal aorta below the coarctation and the right renal artery, which was extremely small. The blood pressure fell temporarily but then suddenly rose to 210/200. It was concluded that the graft was not functioning and a right nephrectomy was performed. The patient had been normotensive for nineteen months at the time of writing.

This case report demonstrates two important points: (1) Aortography is essential in determining the location of the stenosis in its relation to other major vessels in order that optimum bypass or replacement grafts may

be instituted. (2) Selective renal function studies are mandatory since intravenous pyelography cannot be relied upon to provide the information necessary to establish the cause of the hypertension. Neither the filtration rate nor the rate of blood flow is ascertainable from the nephrogram or pyelogram. In short, renal function cannot be determined by pyelography even though the osmolality of the urine from each kidney is known. An ischemic kidney may excrete a urine of higher osmolality than its normal partner and, consequently, may be more radiopaque.

Two roentgenograms; 2 diagrams; 1 pressure tracing; 2 tables.

JOHN P. FOTOPOULOS, M.D.
Northwestern University Medical School

Extravasation of Contrast Medium as Roentgen Criterion of Cardiac Necrosis in Dogs Following Intracoronary Injection of Urokon. M. J. Oppenheimer, C. Harakal, R. Sherwin, L. Howden, W. Winters, and H. M. Stauffer. *Am. J. Roentgenol.* 84: 929-936, November 1960. (Temple University School of Medicine, Philadelphia 40, Penna.)

Reports of ventricular fibrillation following experimental coronary arteriography led the authors to attempt to establish roentgen criteria of cardiac damage by contrast media, if in fact any did exist. Since it has been suggested that damaged hearts release potassium and that this release may be related to infarction, it was decided also to study the role of this ion.

Various radiopaque media and other substances were injected into the coronary arteries of anesthetized dogs, using a nonoccluding catheter introduced via the carotid artery. Cinefluorographic, electrocardiographic, and pulse pressure recordings were made simultaneously. Postmortem examinations were performed on all animals. In most instances, the hearts were prepared according to Schlesinger's method (*Am. Heart J.* 15: 528, 1938), which keeps the right and left coronary circuits separate. The term "infarctoid cardiopathy" was used to indicate tissue damage without vascular occlusion; it was considered to be present if the opaque medium was still visible in the field of the injected artery after five minutes.

Urokon 70 per cent in doses of 0.1 c.c. per kg. consistently produced a persisting roentgenologically demonstrable infarctoid cardiopathy. This was confined to the distribution of the coronary artery injected with the opaque medium. The infarctoid cardiopathy usually appeared with the third or fourth injection and increased a little in extent and intensity as the injections were repeated. The roentgen observations when Urokon and potassium chloride were combined were not different from those when Urokon alone was employed. If a series of potassium injections was completed, a single injection of Urokon often revealed well developed infarctoid cardiopathy, which was much more extensive than any ever observed from a single first dose of Urokon alone. Electrocardiograms obtained after the injection of Urokon showed a change in the direction of the electrical axis of the heart without, or with minimal, associated injury currents.

Renografin produced little or no permanent change in the electrocardiogram or in the normal histology of the myocardium. Hypaque and Vasurix were intermediate in their effects between Renografin and Urokon when electrocardiographic changes were the criteria. Control animals injected repeatedly with Ringer's solution did not exhibit any gross or histologic damage.

The two possible explanations for the action of Urokon are either a brief bout of anoxia while the coronary vessels are filled with a bolus of the medium or an increased permeability of vessels and cell membranes caused by the radiopaque material, augmented by the vasodilatory action of the contrast substance. The authors favor the latter explanation.

Four figures, including 1 roentgenogram.

PHILIP M. JOHNSON, M.D.
Montclair, N. J.

Coronary Angiography. George Michell. M. J. Australia 2: 608-611, Oct. 15, 1960. (St. George's Hospital, London, England)

With the recent advances in treatment of coronary artery disease, techniques for visualization of the coronary arteries have become of more than academic interest. It is desirable to perform coronary angiography (1) in patients who are considered to be suitable candidates for coronary artery surgery; (2) for the objective assessment of surgical and medical treatment, that is, for the evaluation of patients who have had coronary artery surgery and for determining the effect of long-term anticoagulation or unsaturated fat diets; and (3) for the diagnosis of "difficult" or "obscure" chest pain. The exclusion of ischemic heart disease may save a patient many years of anxiety or risky treatment with anticoagulants, while demonstration of a localized lesion may lead to possible surgical relief.

The methods of coronary angiography are briefly reviewed. There are three main techniques for insuring delivery of the contrast medium close to the coronary ostia: (1) occlusive aortography, (2) cardiac arrest, and (3) timing of the injection. Occlusive aortography is technically difficult. Acetylcholine arrest is considered potentially dangerous. The author's procedure consists in timing of the injection of the medium in relation to the cardiac cycle. Maximal coronary flow occurs during ventricular diastole; during systole, flow may actually be reversed. An electronic timing device has been developed which is triggered by the R wave of the electrocardiogram. This timer permits a single x-ray exposure to be made automatically at any desired time or it will initiate a serial changer. (The device is described in detail in *Clinical Radiology* 11: 214, 1960. See following abstract.)

Experiments in dogs showed that injection of the medium during systole resulted in poor coronary filling, whereas diastolic injection led to consistently good opacification. The proximal part of the coronary tree was filled at the end of the diastolic period in which the injection was given; distal filling, with poor proximal opacification, did not occur until the end of the following diastole. It was then decided to test the effect of multiple diastolic injections. A new electronic timer was devised for this purpose, which allows the total dose of contrast medium to be divided into two or more equal parts and injected over two or more successive diastoles. With this timer it was found that multiple injections resulted in complete coronary opacification on one roentgenogram. Treble injections resulted in better filling of the small distal branches. Multiple injections are advantageous because it is possible to obtain an x-ray picture of the whole coronary tree on a single film, eliminating expensive and complicated radiographic apparatus and reducing the irradiation. In man, it is difficult to inject 60 to 80 ml. of medium over one diastolic period without placing a tremendous strain

on the angiographic equipment and catheters; with a double or treble injection it is possible to inject the total dose quite comfortably.

The above procedure has never failed to produce coronary opacification in experimental animals, and there have been no instances of electrocardiographic changes following angiography and no deaths attributable to the injection of the medium. Multiple diastolic injections have been employed in 3 patients, using a serial changer; the angiograms were all good and there were no immediate or remote complications.

Four roentgenograms; 4 electrocardiographic tracings.

CAPT. HOWARD R. GOULD, M.C.
Loring AFB, Maine

Timing of Injections for Angiocardiography: Description of an Automatic Device. J. G. Davies and George Michell. *Clin. Radiol. (J. Fac. Radiologists)* 11: 214-218, October 1960. (St. George's Hospital, London, England)

The authors describe in detail their apparatus for automatic timing of injections for angiocardiography, with the circuit diagram. The device is triggered by the R wave of the electrocardiogram. Its application in coronary angiography, aortic valve visualization, and left ventriculography is discussed. [See also preceding abstract.]

Six roentgenograms; 3 electrocardiograms; 1 pressure tracing.

THEODORE E. KEATS, M.D.
University of Missouri

Clinical Application of Coronary Angiography. Graeme Sloman and W. S. C. Hare. M. J. Australia 2: 611-614, Oct. 15, 1960. (The Royal Melbourne Hospital, Melbourne, Australia)

Coronary angiography enables one to determine the location or extent of coronary artery disease, which is difficult to evaluate electrocardiographically when there is no infarction. Accurate demonstration of the coronary arteries also assists in management of patients with obscure anterior chest pain and in the study of the effects of various drugs on the anatomy of the coronary circulation. The authors describe a method of coronary angiography which utilizes a single timed injection triggered by the R wave of the electrocardiogram.

Thoracic aortography was carried out on 20 patients, with an average age of forty-four years. The ascending aorta was catheterized via the right brachial artery in 14 patients; in the other 6, Seldinger's percutaneous technic was used to catheterize the ascending aorta via a femoral artery. An image intensifier was employed for positioning the catheter. The contrast medium was 76 per cent Urografin, 0.75 ml. per kg. body weight, with a maximum of 50 ml. being given to opacify the ascending aorta. The injection was made in approximately one second, with a simple compressed-air mechanical injector. An Elema-Schönander single-plane roll-film camera was utilized. Although transient ST-T wave depression was noted on a number of occasions, no patient complained of anterior chest pain associated with the injection of contrast medium.

Technically satisfactory angiograms were obtained in 12 of the 20 patients. Unsatisfactory angiograms were due, for the most part, to the placing of the catheter tip at too high a level. Fourteen patients had aortic valve disease, 2 had combined mitral and aortic stenosis, and the remaining 4 had a variety of conditions. In 11 of the patients, the angiographic findings

were verified at operation or at postmortem study.

No serious complications were encountered. On one occasion, the right coronary artery was inadvertently catheterized, with the patient immediately complaining of anterior chest and neck pain, together with shortness of breath. The electrocardiogram showed ST-T elevation with a change in the pressure recording. Symptoms were relieved immediately upon withdrawal of the catheter. No patient suffered from any limb ischemia following arterial catheterization; however, a hematoma developed in 1 case at the site of the puncture of the right femoral artery.

Two roentgenograms; a schematic diagram; 1 electrocardiogram. CAPT. HOWARD R. GOULD, M.C. Loring AFB, Maine

Angiography in Leprosy. S. P. Basu, S. Ghosh, N. Mukerjee, and K. P. Roy. Indian J. Radiol. 14: 180-190, November 1960. (School of Tropical Medicine, Calcutta, India)

Whether the blood vessels play an important part in the neural manifestations of nonlepromatous leprosy has not been definitely established. Faget and Mayoral (Radiology 42: 1, 1944), for example, concluded from their arteriographic studies that the arterial circulation of the extremities is not materially disturbed in this condition.

Arteriography of the affected upper extremity was performed by the authors in 20 cases of leprosy of the nonlepromatous type to detect any change in the hemodynamics. Four patients with leprosy with unaffected upper extremities and 5 with other skin conditions served as controls. Vascular changes in the form of a circulatory stasis in the digits were demonstrated in some cases. This stasis was not dependent on the duration of the disease. In a case with associated bone absorption, the vessels appeared thinner and there was delay in emptying due to venous stasis. Usually there was good filling at five seconds. A shunt was observed in most of the control cases, producing a poor filling of the digital vessels.

The findings in the 20 cases are presented.

Six roentgenograms. WENDELL M. BURNS, M.D. Covina, Calif.

Percutaneous Retrograde Thoracic Aortography and Levocardiography. P. Thurn, A. Schaede, H. H. Hilger, and A. Düx. Fortschr. a. d. Geb. d. Röntgenstrahlen 93: 393-418, October 1960. (In German) (Medizinische Klinik der Universität Bonn, Germany)

Percutaneous retrograde levocardiography and aortography make possible selective visualization of the left heart chambers and of the aorta with its branches. They have been used routinely in 68 consecutive cases.

The procedure is done under general anesthesia with preliminary sedation. A femoral artery is punctured percutaneously. A thin catheter is introduced and is led upward to the base of the aorta. Passage into the left ventricle can be easily accomplished except in extreme stenosis of the aortic valve. The right brachial artery may have to be used instead of a femoral artery in far advanced coarctation of the thoracic aorta. Pressure readings are taken in the left ventricle and aorta, and are followed by rapid injection of Renografin (76 per cent). The adult dose is 50 c.c. in aortography and 60 to 70 c.c. in levocardiography. Continuous electrocardiographic tracings are taken throughout the pro-

cedure. After completion of the study and withdrawal of the catheter, manual compression of the femoral artery is required for ten to fifteen minutes.

Indications for aortography are: (1) patent ductus arteriosus, (2) obliteration of the subclavian artery, (3) anomalies of the aortic arch and of cervical arteries, (4) aortic isthmus stenosis, (5) aneurysm of the sinus Valvulae, with and without perforation into a cardiac chamber, and other types of aneurysm, (6) anomalous coronary orifices, as fistulas between a coronary artery and a chamber or the pulmonary artery. The procedure is also useful for "aimed coronaryography" in coronary disease.

Indications for levocardiography are: (1) aortic stenosis (valvular, subvalvular, and supravalvular), (2) idiopathic hypertrophy, Bernheim syndrome, endocardial fibroelastosis, tumor, and constrictive pericarditis, (3) aortic insufficiency, especially in high septal defect, (4) mitral insufficiency, (5) combined mitral-aortic lesions, especially preoperatively in mitral stenosis, (6) ventricular septal defect with left-to-right shunt for preoperative localization of defect, and (7) transposition of the great vessels.

Fifteen different conditions are illustrated with roentgenograms, electrocardiograms, and pressure curves. The differential diagnosis of aortic stenosis, mitral insufficiency, and ventricular septal defect is discussed in detail, and it is stressed that proper evaluation of reflux from the left ventricle into a dilated left atrium during levocardiography requires continuous electrocardiographic monitoring.

Twenty-nine roentgenograms; 9 electrocardiograms. ERNEST KRAFT, M.D. Northport, N. Y.

THE DIGESTIVE SYSTEM

Dysphagia Lusoria Presenting as a Superior Mediastinal Syndrome. Roy Morris. Brit. M. J. 2: 1558-1561, Nov. 26, 1960. (Johannesburg, Union of South Africa)

In the adult the term dysphagia lusoria usually denotes esophageal compression by an aberrant right subclavian artery. The author reports what is believed to be the first case of adult dysphagia lusoria presenting as a superior mediastinal syndrome to be recorded in the English-language literature and the first case in an adult to be treated surgically.

The patient, a 54-year-old woman, had for about twenty-five years constant dysphagia of variable intensity, associated for fourteen years with orthopnea and episodically with swelling of the neck, hoarseness, and a "choking" sensation. On physical examination the neck appeared swollen, suggesting thyroid enlargement. The external jugular vein was not distended, but the veins of the optic fundi were engorged. The clinical impression was that of a retrosternal goiter which had undergone a recent hemorrhage. Roentgen examination, however, revealed a defect in the esophagus, caused by an aberrant vessel. Aortography confirmed the presence of an aberrant right subclavian artery with a slight dilatation at its origin. At thoracotomy, the aberrant artery was found to arise about 0.5 cm. beyond the left subclavian from the posterior aspect of the aortic arch. That segment crossing the esophagus was ligated and excised. The patient rapidly recovered from the operation and all symptoms immediately disappeared. At follow-up examination, the optic fundi

appeared normal and there was no thyroid swelling.

Embryologically, an arteria lusoria represents the persisting distal descending portion of the fourth right aortic arch; the persistence of this arch leads to the formation of an aberrant right subclavian artery. At the origin of the abnormal vessel there may be an aneurysmal dilatation known as the diverticulum of Kommerell. From the left side of the aortic arch, the aberrant artery courses to the right in one of three ways. It may run behind the esophagus (80 per cent of cases), between the esophagus and trachea (15 per cent), or in front of the trachea and esophagus (5 per cent). The commonest and mildest complaint is a feeling of food sticking under the manubrium sterni, which is often attributed to a *globus hysterius*. The dysphagia may be mild and chronic, it may become progressively worse, or it may be fairly severe with acute exacerbations, as in the author's case.

An esophagram, in frontal projection, reveals a defect about 0.5 cm. wide passing upward from left to right on the posterior aspect of the esophagus just above the aortic arch. An excess of barium sulfate may obscure the defect. In oblique views of the esophagus the abnormal vessel produces a typical notch. Should the vessel course in front of the trachea, no esophageal defect will be encountered. Angiography may be employed to demonstrate the aberrant vessel but is hazardous and is better avoided. Esophagoscopy will reveal the presence of a pulsatile esophageal defect, either anteriorly or posteriorly, in about 40 per cent of cases. The diagnosis may also be made by right subclavian artery catheterization, but the symptoms are usually so mild that this procedure is not warranted.

Four roentgenograms; 3 drawings.

PHILIP M. JOHNSON, M.D.
Montclair, N. J.

One Hundred Consecutive Cases of Dysphagia: Some Problems in Diagnosis. G. Osborne, Paul T. Savage, and S. L. Strange. *Clin. Radiol. (J. Fac. Radiologists)* 11: 250-265, October 1960. (The Whittington Hospital, London, N. 19, England)

The authors review their experience with 100 consecutive cases of dysphagia seen in a general hospital. The various causes of dysphagia found in this series were carcinoma of the esophagus, 11 cases; malignant neoplasm of stomach, 19 (carcinoma, 18; reticulosarcoma, 1); carcinoma of bronchus, 4; cardiospasm, 6; hiatus hernia, 27; complications incident to operations on the stomach, 4; miscellaneous, including webs and pharyngeal pouches, 8. In 21 patients no organic cause for the dysphagia was discovered.

The diagnostic problems encountered are discussed. Special reference is made to the simulation of esophageal carcinoma by bronchial carcinoma, to the distinction between benign and malignant strictures associated with hiatus hernia, and to x-ray negative dysphagia.

Thirty-two roentgenograms; 2 drawings; 1 photograph; 2 tables.

THEODORE E. KEATS, M.D.
University of Missouri

Narrow Esophagogastric Ring Treated Endoscopically. Max L. Som, Bernard S. Wolf, and Richard H. Marshak. *Gastroenterology* 39: 634-638, November 1960. (B.S.W., The Mount Sinai Hospital, New York 29, N.Y.)

The literature on esophagogastric rings is reviewed briefly, and a case is reported to illustrate the typical

history and to show that endoscopic rupture may furnish relief of symptoms.

The patient was completely well until the age of twenty-eight, when he started to have intermittent dysphagia with coarse-grained foods, such as meat. Food would not go down, and though he tried to regurgitate he was unable to do so. Sometimes efforts over a period of an hour succeeded in bringing up particles of food that he had recently eaten, accompanied by large quantities of mucus. Roentgen examination of the esophagus on two occasions was reported as normal. Finally, a severe episode lasting six hours occurred. At this time fluoroscopy disclosed a typical constriction ring, 3 cm. above the hiatus of the diaphragm. By using a compressed barium tablet of known size, the diameter of the ring was judged to be 10.3 mm. The fold pattern of the viscera distal to the site of the ring was thick and resembled gastric rugae. Esophagoscopy was performed with an esophagoscope much wider than usual (16 mm. in outside diameter). At 40 cm. from the upper incisor teeth, the lumen of the esophagus was narrowed by a constriction covered by smooth, pale mucosa through which the instrument could not be passed. Gastric rugae could be identified beyond the constriction. An esophageal forceps with a right angle punch was used to sever the ring; the lumen promptly gaped open and the esophagoscope could be passed into the stomach. All symptoms were completely relieved. Repeat roentgen examination, several months later, still demonstrated a ring but the same sized barium tablet passed easily, indicating that the diameter of the ring was at least 12.5 mm.

The importance of using an esophagoscope with a caliber greater than the ring in order to visualize and treat it endoscopically is emphasized. An esophagoscope of 10 or 12 mm. diameter may easily slip through a clinically significant constriction.

Three roentgenograms.

CAPT. HOWARD R. GOULD, M.C.
Loring AFB, Maine

Regional Jejunitis. Leon Ginzburg, Richard H. Marshak, and Joan Eliasoph. *Surg., Gynec. & Obst.* 111: 626-632, November 1960. (The Mount Sinai Hospital, New York 29, N.Y.)

Regional jejunitis is an uncommon form of regional enteritis in which the initial manifestations are mainly or exclusively in the jejunum. The authors describe the pathologic, clinical, and roentgenologic findings in 22 cases in which granulomatous enteritis was confined originally to the jejunum.

The areas of involvement are much shorter in regional jejunitis than in ileitis. Long, continuous, segmental involvement which in distal ileitis may extend for 3 or 4 feet is not observed as a rule. Diseased segments longer than 6 or 12 inches are uncommon. Most are even shorter and are frequently annular. When a single stenotic lesion is present, there is continuous dilation of the proximal bowel. More commonly, however, multiple stenotic segments are encountered.

In distal ileitis the roentgen picture is dominated by the appearance of diseased segments of bowel. In regional jejunitis, on the other hand, the sequelae of the diseased stenotic segments, namely, markedly dilated, chronically obstructed loops, are the striking finding. The retention of food and secretions and the inflammatory reaction which frequently develops in these chronically obstructed loops produce roentgen

ure may fur-

I the age of intermittent such as meat ed to regur- efforts over a particles of ed by large of the as normal s occurred constriction m. By us- size, the di- m. The fold the ring was endoscopy was wider than 10 cm. from phagus was smooth, pale

ould not be beyond the right angle and promptly passed into rectum. I relieved. months later, barium diameter of

pe with a alizalize and esophago- p through

o, M.C.

Maine

Richard H. & Obst. Mount Sinai

of regional are mainly describe findings was con-

o regional segmental for 3 or segments. Most are

When a ous dilat- ly, how- ed. Eliminated vel. In cluelae of markedly striking and the loops in roentgen

features which are characteristic of prolonged obstruction. The diameter of the doubly obstructed loops may attain the proportions of a markedly distended colon. In most instances the stenotic segments are easily visualized; however, numerous, overlapping dilated intestinal loops may make a single, short stricture difficult to delineate. The contours of the narrowed segments are usually smooth and the lumen is concentrically located. The mucosa may be cast-like or exhibit numerous pseudopolyps and ulcerations. The stenotic segments are rigid. The presence of skip lesions may result in a "hammock type" or "sausage link" type of deformity. When the obstruction is high, duodenal and even gastric dilatation may be evident. Fistulas, abscess formation, and sinus tracts are rarely seen.

The roentgen picture is as a rule sufficiently distinctive that diagnosis presents little difficulty. In an occasional case, Hodgkin's disease or lymphosarcoma may produce a similar appearance, especially to the nonstenosing phase of jejunitis. Differentiation may be impossible.

While carcinoma has been observed only once in hundreds of cases of distal ileitis, a highly malignant form of adenocarcinoma developed in 1 of the 22 patients in the present series. The authors have seen one other case of carcinoma arising in an area of regional jejunitis. This case was not included in this series because the terminal ileum was also involved.

Treatment is usually symptomatic until prolonged obstruction supervenes. When surgical intervention becomes necessary, resection is the procedure of choice. Extension of disease after operation is common, but the relief from symptoms may be remarkable.

Eleven roentgenograms.

MORTIMER R. CAMEL, M.D.
Brooklyn, N. Y.

A Simple Experiment in Small-Bowel Motility. Charles M. Nice, Jr. *Indian J. Radiol.* 14: 149-161, November 1960. (Tulane University School of Medicine, New Orleans 12, La.)

The type and volume of barium preparation, the position of the patient, and state of evacuation of the colon were investigated relative to the rate of motility and quality of the roentgenographic pattern of the small intestine in over 200 students at Tulane University School of Medicine. On the basis of the findings with different methods of examination, the following regimen is suggested for the roentgenologic study of the small intestine: (1) The colon is emptied with laxatives, or enemas, as for a barium-enema examination. Nothing is taken by mouth after the laxative. (2) Ten ounces of the usual barium suspension is given by mouth during fluoroscopy of the esophagus, stomach, and duodenum, with roentgenograms as indicated. (3) The patient is asked to assume the right lateral recumbent position. (4) Twenty minutes later, roentgenograms are taken in the supine position to show upper small intestinal loops. (5) Thirty minutes later, fluoroscopy is performed to visualize, palpate, and separate loops; 10 ounces of water is given by mouth. (6) Forty minutes later, a prone film of the abdomen is obtained. (7) Sixty minutes later, fluoroscopy is again done to see if the barium has reached the cecum. If it has not, more water is given and the patient assumes the right lateral recumbent position for a few minutes longer. When fluoroscopy reveals barium in the cecum, spot films are

obtained of the terminal ileum and ileocecal valve region with compression. Another prone view of the abdomen is taken at this time.

This procedure will have to be used for some time to see if there is a significant increase or decrease in the accuracy of detection of lesions. The author is of the impression, however, that one is more likely to discover small defects in the barium column than with other methods. Certainly one can evaluate such findings as segmentation and partial constriction more easily.

Seven roentgenograms; 4 tables.

WENDELL M. BURNS, M.D.
Covina, Calif.

A Roentgenologic Study of the Course of Ulcerative Colitis. N. P. G. Edling and O. Eklöf. *Acta radiol.* 54: 397-409, November 1960. (Karolinska Sjukhuset, Stockholm, Sweden)

The authors investigated the course of ulcerative colitis in a series of 140 cases to ascertain the value of the roentgen findings in the prognosis and treatment. The roentgen examination consisted of the conventional barium-enema study, with special projections of the rectum and sigmoid colon, flexures, and ileocecal region, as well as general views of the large intestine after filling and evacuation.

An analysis of the distribution according to the age at onset and to the extent and severity of the disease revealed that more extensive and severe lesions developed in cases with early onset than in those occurring later. The earlier the onset the more marked were the subsequent changes. And the incidence of normal roentgen findings was highest in the cases of late onset. All cases with involvement of the terminal ileum in addition to the large intestine, as well as the great majority of those with involvement of the large intestine alone, exhibited marked inflammatory changes in the bowel wall. Most of the cases with lesions confined to the distal parts of the large intestine, or to the rectum alone, showed moderate wall changes. On the whole the extent of the inflammatory condition was commensurate with the degree of change present. Marked and moderate changes were found in almost equal numbers of cases. The progressive and regressive groups comprised fairly equal numbers of cases with marked and moderate changes; the roentgen course sometimes showed exacerbations and remissions but in the main a steady regression or progression.

Malignant degeneration occurred in 19 of the 140 patients. Nearly half the tumors were observed in patients who were under fifteen years of age at the onset of the colitis, though these patients constituted only one-fifth of the series.

An increase of the presacral soft tissue space was demonstrated in 38 cases. The incidence of malignancy in this group was on a par with, and the ulcerative colitis mortality higher than, the average in the series.

"To sum up, as regards the course of the ulcerative colitis itself, the findings at the initial roentgenologic examination provide no true guidance, but follow-up examinations showed a poorer prognosis for the progressive than for the recessive cases. As regards malignancy, on the other hand, marked and extensive initial lesions may develop into graver conditions than do moderate lesions, but the outcome could not be predicted from the course of the inflammatory process."

The authors stress that the absence of retrograde filling of the terminal ileum in a barium-enema study

unconditionally calls for a barium meal and examination of the ileocecal valve and terminal ileum.

Eleven roentgenograms; 1 diagram; 7 tables.

THEODORE E. KEATS, M.D.
University of Missouri

Giant Cyst of the Common Bile Duct. Preoperative Visualization by Transhepatic Cholangiography in 2 Cases. Alberto Jamis-Muñoz. *Am. J. Digest. Dis.* 5: 935-944, November 1960. (Hospital de Barranquilla, Barranquilla, Colombia, S. A.)

Congenital dilatation of the common bile duct is a rare anomaly. The cause is unknown; some think it is due to an inherent weakness of the walls of the common bile duct; others attribute it to the lack of contractile elements in the duct, with dilatation considered the result of a distal obstruction. The cyst-like dilatation may contain up to 8,000 ml. of bile. Generally, there is no biliary lithiasis, but cholangitis is frequent, as are functional alterations of the liver and biliary cirrhosis.

The diagnosis is based on the presence of jaundice, an abdominal mass, and pain. The majority of cases occur in children. The differential diagnosis must exclude pancreatic and hepatic cysts, tumors of the retroperitoneum, kidney, and liver, and other anomalies of the biliary tract. Usually the correct diagnosis is not made until laparotomy. Gastrointestinal studies show displacement of the stomach and duodenum by a cystic mass.

The author reports the first 2 cases diagnosed preoperatively by the roentgenographic visualization of the giant cysts following injection of contrast medium and air, in 1 case through a polyvinyl tube introduced into the intrahepatic biliary tree and in the other by intrahepatic puncture. In both instances the enormous dilatation of the common bile duct was identifiable preoperatively.

Choledochocysticoduodenostomy was performed in both patients, with relief of symptoms. Postoperative roentgen studies in the first patient showed a tendency for the common bile duct to resume its normal size and shape.

Sixteen roentgenograms.

MORTIMER R. CAMIEL, M.D.
Brooklyn, N. Y.

The Sphincter of Oddi and Gallbladder Function: I. Preservation of Function after Section and Resection of the Sphincter. Robert E. Lempke. *Ann. Surg.* 152: 815-826, November 1960. (VA Hospital, Indianapolis, Ind.)

Eight consecutive patients in whom the sphincter of Oddi was sectioned or resected, without prior or concomitant cholecystectomy, were shown by oral cholecystography to have a functioning gallbladder after intervals ranging up to two years.

Oral cholecystography is a simple direct method of evaluating the effect of sphincter destruction on the function of the gallbladder, though it has been little used in the study of this problem. Of the author's 8 patients, 6 retained essentially normal and 2 reduced gallbladder function as determined by oral cholecystography. Reflux of barium into the common duct during upper gastrointestinal study was suspected in 1 patient and was definite in another. The latter was the only patient in whom cholecystitis developed.

Preservation of function on oral cholecystography does not preclude the existence of cholecystitis even in

the absence of definite symptomatology. Neither does an apparent decrease in the density of the gallbladder image necessarily indicate disease of that organ, since absorption of the contrast material may be impaired by intestinal factors such as increased motility secondary to pancreatic insufficiency. It is significant, however, that the gallbladder did fill well enough to demonstrate some function in every case and that the reduced function in 2 patients, as well as the absence of visualization in previously recorded cases, was associated with chole-dochoduodenal incompetence.

Thirteen roentgenograms; 2 drawings; 3 photomicrographs.

THE MUSCULOSKELETAL SYSTEM

Soft-Tissue Changes and Radiological Early Diagnosis of Acute Osteomyelitis in Children. A. Giedion. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 93: 455-460, October 1960. (In German) (Universitäts-Kinderklinik Zürich, Switzerland)

In acute osteomyelitis the first diagnosis has to be based primarily on clinical findings. The visible bone changes represent a late manifestation of the disease, osseous and periosteal lesions being seen roentgenologically ten to fourteen days after the onset of symptoms. Early roentgen signs in the soft tissues have to be relied upon. These consist of disappearance of fat spaces near a joint and swelling of contiguous muscles. Finally, the subcutaneous layers become obliterated and a massive edema develops. Comparative radiologic studies of the normal contralateral side are helpful in coming to definite conclusions.

Of special significance is the development of the lesions in an outward direction from the inside, whereas ordinary skin infections extend only superficially. Diagnostically important is a metaphyseal involvement, with the nearby joint remaining intact. This localization prevents confusion with septic arthritis.

The author reports on 23 children, 5 below the age of five, 6 between five and ten years, and 12 between ten and sixteen years. The distal femur was affected in 7 cases, the proximal tibia in 6, the proximal humerus in 3, and the distal tibia in 3. In the 4 remaining cases the proximal femur, the distal humerus, the distal fibula, and the calcaneus, respectively, were the sites of the involvement. In most instances treatment was symptomatic, with antibiotics during the first week of illness, although no definite diagnosis had been established. This form of treatment resulted in an atypical course with delay of visible bone changes for three weeks or longer.

Five cases are reported and illustrated: in the distal fibula, the distal femur, the humerus, the calcaneus, and the tibia. Most of these were not correctly diagnosed or treated until the roentgenograms showed the described soft-tissue changes, suggesting an early phase of acute osteomyelitis.

Thirteen roentgenograms; 3 drawings; 1 chart; 3 tables.

ERNEST KRAFT, M.D.
Northport, N. Y.

Massive Osteolysis of Bone: Report of a Fatal Case with Temporary Reconstitution of the Affected Bone Following Irradiation. John M. Fiore and William T. Smyth. *Ann. Int. Med.* 53: 807-816, October 1960. (VA Hospital, Albany, N. Y.)

The syndrome of acute spontaneous absorption of

Neither does the gallbladder organ, since it is impaired by secondary gallbladder, however, to demonstrate reduced function visualization with chole-

3 photomicro-

STEM

Early Diagnosis
A. Giedion
93: 455-460,
Kinder-

sis has to be visible bone of the disease, roentgenologic symptoms to be relieved of fat spaces muscles. Fibroblasts and a radiographic are helpful in

ment of the side, whereas superficially, involvement. This localiza-

now the age of 12 between as affected in the humerus, remaining cases distal fibula, sites of the it was symptom of illness, established typical course three weeks or

in the distal clavicle, andy diagnosed involved the early phase of

1 chart, 3
APT, M.D.
port, N.Y.

a Fatal Case
ected Bone
William T.
October 1960
sorption of

bone is a rather rare and poorly understood condition. It is often referred to under such descriptive titles as "disappearing bone," "acute spontaneous absorption of bone," and "idiopathic osteolysis of bone." Approximately 30 cases have now been recorded in the literature. As a rule, the patient is a young adult in good health; minor trauma, usually to the affected area, calls attention to the lesion. Pain is not a striking symptom. There is no sex predilection. In some cases, the lesion reaches a certain size and then becomes static; in others, it may progress to extensive destruction of the affected bone and of the contiguous bony structures. The latter variety is usually associated with a neoplasm, e.g., lymphangioma or hemangioma.

In some instances, the etiology of "disappearing bone" is obvious, i.e., hemangioma of bone, lymphangioma of bone, or nonunion of fractures with resorption of varying amounts of the distal fragment. No common denominator is apparent in other cases. Parathyroid tumors have been sought for but so far have not been found. The osteolysis has also been attributed to a disturbed blood supply and to neurotrophic changes.

The authors report a case of massive osteolysis in a 26-year-old white male whose initial complaint was pain in the knee. Roentgen examination of the pelvis revealed osteolysis of the superior and inferior rami of the left pubis. There was also slight deviation of the left side of the bladder toward the midline. A study of the urinary tract disclosed a moderately severe left hydronephrosis. A biopsy of the left pubis was reported as showing dense fibrous tissue. Laboratory studies were noncontributory.

In an attempt to aid the patient, roentgen therapy was given, 2,200 r being delivered to each of two ports over a period of thirty-six days. Within six days there was a significant decrease in the hip pain. Roentgenograms taken approximately two months after initiation of irradiation showed a significant degree of bone regeneration. By seven months after irradiation, almost complete regeneration of the bony structures had taken place, and the hydronephrosis had disappeared. Shortly thereafter, a palpable mass was found in the medial aspect of the upper left thigh. A biopsy of this thigh lesion disclosed a very vascular, undifferentiated sarcoma. Roentgen therapy was administered to the thigh and groin, for a total tumor dose of 3,000 r. The osteolysis recurred, and pulmonary metastases developed. The patient died approximately eleven months after the beginning of the first course of roentgen therapy. At necropsy, no evidence of a primary bone tumor was found, nor was there evidence of a bladder neoplasm.

The authors theorize that in this case the bone disappeared due to local metabolic competition between a malignant process and the adjacent intact skeleton. The case would seem to indicate that irradiation may be of some benefit in arresting the process or in restoring the skeletal structure.

Three roentgenograms; 1 photograph; 2 photomicrographs.

PAUL F. CHRISTENSON, M.D.

Fontana, Calif.

Angiography in Osteoid Osteoma. Å. Lindbom, N. Lindvall, G. Söderberg, and H. Spjut. *Acta radiol.* 54: 327-333, November 1960. (Karolinska Sjukhuset, Stockholm, Sweden)

The nidus of an osteoid osteoma contains many more

vessels than the surrounding bony and soft tissues. The majority of these vessels are slightly dilated capillaries. Angiography with a serial technic was performed by the authors in 2 cases of osteoid osteoma, of the ulna and fibula, respectively. The lesion of the ulna had a typical roentgenographic appearance with marked bony sclerosis around a clearly discernible nidus. In the other the roentgen picture was more unusual. The nidus was large and superficial and probably located chiefly in the periosteum. The proximal end of the fibula was diffusely sclerotic and had a considerably greater diameter than the head of the fibula of the opposite side. In both cases contrast filling of the nidus was obtained in the course of angiography. The lesion in the fibula in the second case was curetted, with a resultant relief of symptoms. Two and a half years after the operation the patient complained of slight pain in the same region. Roentgen examination revealed a small superficial defect in the bone at the same site as the original nidus. Angiography showed this defect to contain highly vascular tissue. At re-examination, five years after surgery, the superficial defect had almost completely disappeared and the upper ends of the fibulae were of almost equal size.

Angiography was also performed in 2 cases of sclerosing osteomyelitis involving the fibula. No increased vascularity in or around the pathologically changed regions could be detected either at angiography or on microscopic examination. It is therefore suggested that angiography may be a useful method of distinguishing osteoid osteoma from bone abscess.

Thirteen roentgenograms; 1 photomicrograph.

JULIAN O. SALIK, M.D.

Baltimore, Md.

Desmoplastic Fibroma. A Report of Three Cases. Thomas E. Whitesides, Jr., and Lauren V. Ackerman. *J. Bone & Joint Surg.* 42-A: 1143-1150, October 1960. (L. V. A., 600 S. Kingshighway, St. Louis 10, Mo.)

The desmoplastic fibroma is an uncommon bone tumor of fibroplastic origin. The few cases recorded have shown a wide age range, and no sexual predilection has been established. The authors present 3 exceptionally interesting examples of desmoplastic fibroma. The tumors were of unusually large size and were not located in the same areas as those reported by Jaffe (*Tumors and Tumorous Conditions of the Bones and Joints*, 1958). One tumor was in the ilium and 2 were in the humerus. Both of the tumors of the humerus crossed into the epiphyseal areas of bone—a behavior not previously noted.

As seen on the roentgenogram, the tumor is usually centrally located and expands the bone cortex. The lesion itself is radiolucent and has a sclerotic and irregular border, giving the illusion of trabeculation similar to that found in unicameral bone cyst or metaphyseal fibrous defect. The apparent trabeculation and bone expansion may also be suggestive of an aneurysmal bone cyst or even a chondromyxoid fibroma. In an extremely large lesion, as in one of the authors' cases, the tumor may replace the entire bone and give an appearance not unlike that occasionally seen in metastatic adenocarcinoma of thyroid or renal origin. The desmoplastic fibroma differs from monostotic fibrous dysplasia in that the tumor tissue does not undergo osseous metaplasia; thus there are no radiopaque areas in the tumor itself. Medullary fibrosarcoma may produce a similar roentgen picture.

Treatment of desmoplastic fibroma should consist in incisional biopsy and then curettage or resection as required by the individual case. Amputation should rarely if ever be necessary. The tumor may be clinically and histologically easily confused with fibrosarcoma; thus an accurate diagnosis is necessary in determining the proper management.

Nine roentgenograms; 1 photograph; 3 photomicrographs. CAPT. SAMUEL S. KRIKORIAN, M.C.

Lackland AFB, Texas

Osseous Lymphogranulomatosis. J. Harder. Fortschr. a. d. Geb. d. Röntgenstrahlen 93: 445-454, October 1960. (In German) (Chirurgische Universitätsklinik München, Germany)

Skeletal changes in lymphogranulomatosis are recognized during life in approximately 5 to 15 per cent of cases. The pathologists, however, report a much higher incidence (55 per cent). This discrepancy suggests that osseous foci frequently escape recognition, especially when only the bone marrow is involved. Roentgenologic visualization is not obtained until the pathologic process extends to cancellous and compact bone.

Primary lesions of the skeleton do not exist since lymphatic involvement is always present. Metastatic spread to bones is usually from adjacent soft tissues, especially the lymph nodes, and hematogenous spread to the calvarium and bone marrow is an exception to the rule.

In a group of 112 cases, osseous involvement was present in only 17 (15.1 per cent) and in 7 of these the bone lesions were multiple. Osteolytic foci were found in 17 locations, osteosclerosis in 4, a mixed type in 3, and honeycomb cystic change with sclerotic trabeculae in 1. Osteolysis with marginal sclerosis was observed quite frequently. The vertebral column was affected in 11 cases, the ribs in 9, the pelvis in 5, the sternum in 3, the femur in 2, and the skull and scapula in 1 each. The lesions simulated either metastatic carcinoma, chronic bone abscess, eosinophilic granuloma, or reticulosarcoma. Lamellated periosteal proliferation of a tubular bone occurred in 1 case, similar to findings in Ewing's sarcoma.

Skeletal involvement is believed to be a late manifestation of the disease, but occasionally it may precede other symptoms and signs by several years. In differential diagnosis, attention is directed to "primary" lymphogranulomatosis of bone, especially in the skull.

Four cases are described, which could be followed for several years, contrary to the usual course of bone involvement in the later phases. A metastatically involved vertebral body was observed to change from an osteosclerotic to an osteoporotic appearance. It is therefore assumed that osteosclerosis represents not a stage during healing but a reactive response to the lymphogranulomatous tissue in the marrow spaces. There may be a long latent period between the occurrence of pain and the first radiologic demonstration of bone changes (in the author's experience three years). Consequently, irradiation should be given if clinical findings suggest bone involvement even though the radiological findings are still negative.

In most instances the response to roentgen therapy was favorable. Small osteolytic foci can be satisfactorily treated with high radiation doses (about 4,000 r) but for other lesions a larger total tumor dose is usually required for effective control. Spontaneous

regression could also be observed. Radiosensitivity did not imply a favorable prognosis.

Eleven roentgenograms. ERNEST KRAFT, M.D.

Northport, N.Y.

Cinemeyelography. Frank P. Smith, Frederick R. Pitts, Jr., and Stanley M. Rogoff. J. Neurosurg. 17: 1112-1115, November 1960. (F. P. S., 280 Crittenden Blvd., Rochester 20, N.Y.)

The authors discuss some of the advantages and limitations of cinemeyelography. The apparatus used for the majority of their cinemeyelograms has been a 5-inch Philips x-ray image intensifier fitted with a 35-mm. Arriflex camera.

Experience with cinemeyelography indicates that its primary role is educational in nature, offering a motion picture to individuals who might otherwise not have an opportunity to witness the fluoroscopic portion of the myelographic examination. A cinemeyelogram may reveal a filling defect overlooked in intermittent fluoroscopy and spot-films, especially when large amounts of Pantopaque are employed and when two or more people are vying for position over the usual fluoroscopic screen. The flow of contrast material through the thoracic spinal canal can be visualized better with cinemeyelography than with routine myelographic technic. If desired, the recording camera may be set over the generally suspected level and a continuous record made as the patient is gradually tilted with the examining unit. In addition, the effects of coughing or straining, which provoke changes in intraspinal pressure, may be studied with cinemeyelography.

Fortunately, the development of the image intensifier has reduced the amount of radiation necessary for adequate exposure of films and the hazard to the patient has decreased. With the maximal time of study limited to a minute and a half, cinemeyelography in the lumbar region delivers approximately the same scattered gonadal dosage as might be received during an intensive gastrointestinal examination, consisting of fluoroscopy and films. In general, lumbar cinemeyelography has not been performed in patients under forty years of age.

One of the limitations of the technic described is that the periscopic viewing device of the image intensifier allows observation by only one person; spot-films, however, may be obtained at any time. The recently developed television monitoring systems facilitate group viewing of the fluoroscopic image during the procedure.

A teaching film has been compiled and may be borrowed on request to Dr. Smith, whose address appears at the beginning of the abstract.

Three roentgenograms.

SAMUEL B. HAVESEN, M.D.

Lynwood, Calif.

Management of Fractures of the Greater Multangular. Report of Five Cases. Lee J. Cordrey and Miguel Ferrer-Torells. J. Bone & Joint Surg. 42-A: 1111-1118, October 1960. (4801 Woodmere, Tampa 9, Fla.)

Since the first carpometacarpal joint is important in the function of the thumb and in performance of strong pinch and grasp, injury to the greater multangular, if not accurately diagnosed and treated, may lead to permanent impairment of function because of pain, limitation of motion, or weakness. Isolated fractures of the

greater multangular are rare and are usually the result of a direct blow to the radiodorsal aspect of the wrist. The typical isolated fracture is a vertical crack through the mid-portion of the bone, with some proximal displacement of the radial fragment. Since the first metacarpal articulates primarily with this fragment, it is displaced proximally from its normal position.

A major cause of error in the diagnosis of fractures of the greater multangular is inadequate roentgenograms. A portion of the greater multangular is obscured on all views except an oblique made with the ulnar border of the hand resting on the cassette and the forearm in 20° of pronation.

Five cases of fracture of the greater multangular treated by open reduction and internal fixation are reported. Three patients had isolated fractures; in 1 patient the fracture was associated with an undisplaced second metacarpal and another with an undisplaced oblique fracture of the proximal phalanx of the thumb.

To achieve a stable, anatomical reduction of the fracture and assure restoration of the articular surfaces of the first carpometacarpal joint, open reduction and internal fixation are recommended. The procedure permits relatively early mobilization of the thumb with minimum danger of displacement of the fracture fragments. Early motion should reduce the risk of contractures of the capsule and thumb web. All 5 patients in the present series regained full motion of the thumb.

Six roentgenograms.

CAPT. ROBERT E. WILDIN, M.C.
Lackland AFB, Texas

Hip Shelves in Children. David M. Bosworth, J. William Fielding, William A. Liebler, Tadao Ishizuka, Hiroshi Ikeuchi, and Paul Cohen. *J. Bone & Joint Surg.* 42-A: 1223-1238, October 1960. (742 Park Ave., New York 21, N. Y.)

The authors report the results of 82 hip-shelf operations on 60 children with unstable hips. (In this study a stable hip is a hip joint in which the relationship of the femoral head to the acetabulum is maintained during stress and during weight-bearing, even though the patient has a limp and a positive Trendelenburg test owing to muscle weakness.) The average age of the children at the time the shelf was applied was 4.6 years. The diseases causing the hip disability were: congenital dislocation of the hip, 30 cases; congenital subluxation of the hip or coxa magna, 7; cerebral palsy, 3; poliomyelitis, 12; old suppurative arthritis, 6; meningocele, 2. No redislocations occurred following shelf applications, except in the 3 patients with cerebral palsy and in 1 of the 2 with meningocele. All of the patients with paralytic dislocation of the hip due to poliomyelitis did well. The period of follow-up after operation ranged from two to twenty years, with an average of 6.3 years.

The age of the patient and the nature of the hip disability (dislocation, subluxation, aplasia of the acetabulum, absorption of a previously applied shelf, or coxa magna) had no influence on the outcome. The operative technic was the essential factor in determining a satisfactory result. It involves the implantation of an adequate sized shelf in a properly located slot at the attachment of the capsule of the hip joint with the distal end of the graft fixed beneath the reflected head of the rectus femoris tendon. No attempt was made to change the position of the femoral head.

Roentgen changes of profound importance were observed in the ilium of all patients. The superior portion of the ilium usually became narrower, whereas the lower part above the acetabulum showed extensive widening. As a result, the appearance of the ilium and hip joint after the shelf procedure often resembled that seen following supra-acetabular pelvic osteotomy. A good part of the benefit from the shelf operation seems to come from this widening of the supra-acetabular portion of the ilium which follows the implantation of the shelf. Both increases and decreases in the density of the bone in the graft and in the ilium were observed roentgenographically at the point of attachment of the shelf to the ilium. Whether these changes represented actual alterations in the bone structure at this point was not determined.

Serial roentgenograms on 14 patients; 1 photograph; 2 drawings. CAPT. SAMUEL S. KRIKORIAN, M.C.
Lackland AFB, Texas

Tomography and Other Radiological Methods in the Management of Congenital Dislocation of the Hip. A. F. Barrett and G. I. Verney. *Brit. J. Radiol.* 33: 684-690, November 1960. (Queen Elizabeth Hospital, Birmingham, England)

This paper is concerned not with the diagnosis of dislocation of the hip but with the radiographic technics employed during its treatment. The difficulties of obtaining a satisfactory demonstration of the relationship between the femoral heads and the acetabula, especially during the stage of immobilization in a plaster of Paris cast, are discussed.

The authors have been using a Siemens multisection apparatus, whereby up to seven cuts either at 0.5 or 1.0-cm. intervals are obtained in a single exposure. In practice, three cuts at 1.0-cm. intervals are usually satisfactory. The top, or anterior, cut is made to pass through the plane half an inch (1.3 cm.) below the skin over the femoral head. In most children between the ages of one and three years, the three cuts pass through the anterior, middle, and posterior parts of the acetabulum. At the time of writing 23 patients had been studied by multisection tomography, for a total of 114 examinations. The results are compared with those obtained by conventional methods, such as single anteroposterior radiograph, lateral radiograph, stereoscopic anteroposterior radiographs, and anteroposterior radiographs with tube shift. Even in dysplastic hips, with poorly ossified heads and despite thick plaster casts, accurate assessment of the femoro-acetabular relationship can be made by multisection tomography. A subluxation of as little as 1.0 cm. in the anteroposterior direction can be recognized by the difference of definition of the femoral heads in the three cuts. When patients are wearing plaster casts, it is the method of choice.

The dose to the ovaries was studied in the 20 females in the series, for both plain radiography and tomography. The estimated ovarian dose during tomography is approximately equal to that for two plain radiographs when the patient is in a plaster cast. Without the plaster cast, the estimated dose with tomography is well under that for the pair of plain radiographs. The reason for this difference is discussed.

Ten roentgenograms; 2 tables.

HAROLD A. SWANSON, M.D.
Calgary General Hospital, Calgary, Alta.

Development of Osseous Changes Associated with Cysts of the Lateral Meniscus of the Knee. E. Jon-
asch. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 93: 466-
471, October 1960. (In German) (Arbeitsunfallkran-
kenhaus Wien, Austria)

Twenty-eight cases of proved cyst of the lateral meniscus of the knee were seen in Dr. Böhler's hospital in Vienna between 1936 and 1959: 22 males and 6 females, with an average age of thirty. In borderline cases routine comparative views of the normal contra-lateral side confirmed the suspicion of minimal alterations. In all surgically verified cases, osseous changes were present at the external tuberosity laterally, slightly below the knee.

Cysts of the lateral meniscus may be recognized on ordinary anteroposterior radiographs. A small exostosis was seen at the insertion of the lateral joint capsule in 4 cases, additional notching immediately below the articular surface in 19 cases, and notching without exostosis in the remaining 5. In some patients it took three years for the full development of the changes. There was no regression, and the altered contour proved irreversible according to follow-up studies which in 1 case were continued for twenty years after removal of the cyst.

The growth of a cyst causes traction of the periosteum with resulting exostosis. As the cyst increases in size, pressure on the adjacent bone tends to produce the associated notching in most instances.

In conclusion, it is stated that all lateral meniscus cysts will in time produce characteristic roentgen changes of the lateral contour of the external tibial tuberosity.

Fifteen roentgenograms. ERNEST KRAFT, M.D.
Northport, N. Y.

A Device for Stress Inversion or Eversion Roentgenograms of the Ankle. Elias D. Sedlin. *J. Bone & Joint Surg.* 42-A: 1184-1190, October 1960. (The Henry Ford Hospital, Detroit 2, Mich.)

The author describes an inexpensive device for maintaining stress on the ankle in inversion or eversion while roentgenograms are being made for the evaluation of ligamentous injuries. The device consists of a foot piece, an anchoring thigh strap, and two connective ropes. It has been employed to make stress roentgenograms of both ankles of over 150 patients, and there is no evidence that stress testing increased the extent of the injuries.

The amount of stress applied in the normal ankle is just that needed to cause discomfort, and in the anesthetized, acutely injured ankle it is the amount required to invert the ankle to the point where resistance to further inversion is felt. Roentgenograms in the anteroposterior projection are obtained and the talar-tilt angle (the angle formed by the tibial and talar articular surfaces) is measured, using a method similar to that outlined by Rubin and Witten (*J. Bone & Joint Surg.* 42-A: 311, 1960. *Abst. in Radiology* 76: 161, 1961). A maximum tilt of 14° was found in unanesthetized normal ankles of patients with acute, contralateral injuries. In normal ankles tested under general anesthesia the tilt was only 8°. The maximum variation between right and left ankles in normal persons was 10°. In anesthetized, injured ankles, the talar tilt ranged from 0 to 70°. As a rough guide, 15° has been accepted as the upper limit of tilt in a normal

ankle. Rubin and Witten believe that a talar-tilt angle of less than 23° is not a reliable indication of rupture of the fibular collateral ligament. The author feels that the injured ankle which exhibits talar tilt ranging from 10 to 15° presents the greatest source of possible diagnostic error.

Forty of the 125 acutely injured ankles were explored surgically. In general it was found that a frank tear of the ankle did not exist if the talar tilt angle was less than 15°. The extent of damage found at operation was positively associated with the degree of tilt measured.

Stress testing with the device described is indicated (1) in patients with a history of severe disability developing promptly at the time of injury, of rapid onset of edema and ecchymosis after injury, and of an injury involving moderate to major stress; (2) when physical examination reveals ecchymosis, severe edema, marked tenderness localized to the collateral ligaments, clinical instability, and marked pain on weight-bearing; (3) when routine anteroposterior, lateral, and oblique views fail to demonstrate pathological changes that are consistent with the history and physical findings.

Four roentgenograms; 4 photographs.

CAPT. JOHN C. RAMBEAU, JR., M.C.
Lackland AFB, Texas

Narrowing of the Intervertebral-Disc Space in Children. Presumably an Infectious Lesion of the Disc. James R. Doyle. *J. Bone & Joint Surg.* 42-A: 1191-1200, October 1960. (Franklin Hospital, San Francisco 14, Calif.)

The author calls attention to a destructive lesion of the spine in children which involves the intervertebral disk. The presenting symptoms, as well as the physical, laboratory, and roentgen findings, suggest that this is probably an infectious process. The lesion resembles osteomyelitis in many ways, but because of the infrequent and minimal vertebral involvement, it is believed that the condition should be regarded as a separate entity. The findings in 16 children with this disorder are described.

The typical patient is a two-to-four-year-old child who for seven to ten days before admission has symptoms which include fever; stiffness of the back; back or hip pain; limp; refusal to sit, stand, or walk; and unexplained night crying. Although the child does not appear to be acutely ill, he is very irritable and prefers the recumbent position. There is severe spasm of the muscles of the back, with accentuation of the lumbar lordosis. The leukocyte count is slightly elevated, with an increase in the polymorphonuclears. The sedimentation rate is moderately increased at first but returns to normal in four to six weeks. Within one to two weeks, the temperature returns to normal, but the child remains symptomatic for three to four weeks. Roentgenograms of the spine at the onset of symptoms may show no abnormality, but one to two weeks later narrowing of a lumbar intervertebral space may be observed. During the next two to eight months there is gradual widening of the intervertebral space, and in very young children the involved interspace may be restored to virtually normal within one year. Vertebral changes are infrequent and minimal.

A frequent history of trauma, respiratory infection, and diarrhea suggests that the lesion may be the result of transient bacteremia causing infection in an inter-

a talar-tilt
ation of rup-
The author
its talar tilt
est source of
were explored
a frank tear
angle was less
at operation
of tilt meas-
is indicated
ity develop-
aid onset of
of an injury
ien physical
ma, marked
ents, clinical
earing; (3)
nd oblique
ges that are
ings.

R., M.C.
B, Texas

Space in
on of the
urg. 42-A:
pital, San

the lesion of
vertebral
the physi-
that this
resembles
the infre-
is believed
a separate
s disorder

child who
symptoms
neck or hip
and unex-
does not
and prefers
ism of the
the lumbar
elevated,
ars. The
first but
ain in one to
l, but the
ar weeks.
symptoms
weeks later
ay be ob-
s there is
e, and in
ay be
Vertebral
fection,
the result
an inter-

vertebral disk rendered somewhat more susceptible by trauma. The fact that in the young child the intervertebral disk receives a blood supply from the surfaces of the adjacent vertebral bodies may explain the occurrence of the lesion in children and also the gradual restoration of the intervertebral space. Biopsies have shown only nonspecific inflammation. Treatment of the patients in the present series included bedrest, use of back supports, and antibiotics, all measures of unproved value.

Nineteen roentgenograms; 1 table.

CAPT. ROBERT E. WILDIN, M.C.
Lackland AFB, Texas

GYNECOLOGY AND OBSTETRICS

Observations on the Use of Aqueous Contrast Media in Hysterosalpingography. A. Ribeiro. Indian J. Radiol. 14: 162-169, November 1960. (King George's Medical College, Lucknow, India)

With the use of oily contrast media in hysterosalpingography, there exists the risk of oil embolism as well as failure to enter a stenosed tube, delayed absorption causing foreign-body reactions in the pelvic peritoneum with peritubal adhesions, and unsatisfactory demonstration of hydrosalpinx. Because of these, the author investigated four water-soluble contrast materials. Fifty patients were examined: 18 with Diagnol 50 per cent (iodine content 33 per cent); 2 with Billigrafim Forte (iodine content 25 per cent); 8 with Hydrombrine 60 (iodine content 25 per cent); 22 with Diagnol Viscous 40 per cent (iodine content 26 per cent). Fluoroscopy was used as an adjunct in 7 cases but the results were poor and the author concludes it should not be a routine procedure. No grave reactions were encountered in the series. Hydrombrine caused more chemical irritation of the peritoneum than the other media. Other toxic symptoms observed were fever with rigor, low back pain, headache, excessive thirst, urethral burning, and a generalized feeling of warmth.

The technic is described in detail. It is to be noted that never more than 10 c.c. were required for diagnostic studies and that the contrast material was rapidly absorbed, all of it disappearing from the peritoneum in sixty to ninety minutes.

All four of the contrast media were satisfactory, but the Diagnol Viscous 40 per cent is recommended because of its greater opacification and less transient toxicity.

Six roentgenograms; 1 table.

WENDELL M. BURNS, M.D.
Covina, Calif.

Hysterosalpingography with Water Soluble Medium (Salpix). George W. Henry and Robert G. Hunter. Am. J. Roentgenol. 84: 924-928, November 1960. (1133 Punchbowl, Honolulu, Hawaii)

In hysterosalpingography the aqueous contrast agents are preferable to the oily media because of their clinical safety and complete absorption. The authors have employed Salpix (0.32 gm. polyvinylpyrrolidone per cubic centimeter plus 0.32 gm. sodium acetate per cubic centimeter) in 185 hysterosalpingographic examinations over a period of four years. The patients were ambulatory with complaints chiefly of infertility or habitual abortion. The procedure is carried out at

the estimated date of ovulation; under fluoroscopic control the medium is administered through a specially designed cannula which penetrates the cervical canal only slightly. Usually 4 to 10 ml. of Salpix are instilled. In addition to spot roentgenograms during instillation, frontal and lateral coned Bucky roentgenograms are obtained together with a thirty-minute and/or a one-hour roentgenogram. The medium has given excellent roentgenographic evidence of cervical, uterine, and tubal abnormalities. The chief side effect observed was occasional cramping pain due to entry of contrast material into the peritoneal cavity or to overdistention of the uterus.

The authors dispute published reports that Salpix may produce peritoneal granulomatosis, finding no supporting evidence in their cases. Thirty-three of the examined women in this series became pregnant and delivered normal babies. Laparotomy was performed on 32 patients, primarily for repair of sterility, one month to four years after hysterosalpingography. The majority of these women had peritubal adhesions and Salpix had entered these pockets of the peritoneal cavity. In none of the operated cases or specimens was there any evidence of irritation from the Salpix or suggestion of granulomatous formation. The viscosity of the substance seems ideal and its ability to be absorbed has assisted greatly in the differentiation of free peritoneal spill and loculated peritubal adhesions.

Eight roentgenograms.

PHILIP M. JOHNSON, M.D.
Montclair, N. J.

THE GENITOURINARY SYSTEM

Chronic Pyelonephritis and Vesico-ureteric Reflux. C. J. Hodson and David Edwards. Clin. Radiol. (J. Fac. Radiologists) 11: 219-231, October 1960. (University College Hospital, London, England)

The authors direct attention to the frequent association of chronic pyelonephritis and vesico-ureteric reflux. Among the wide variety of clinical manifestations encountered in these patients, pain in the loin during micturition is the only one which positively suggests reflux. In many patients there is no obvious etiologic factor for the reflux.

The clinical and radiological findings in 10 patients are reviewed and those in another 10 are tabulated.

From the study of these cases, the radiological changes in the urinary tract which are recognized to be associated with reflux are: (1) radiological evidence of chronic pyelonephritis based on the demonstration of localized diminution in thickness of the renal substance, usually accompanied by shrinkage of the adjacent pyramid (calyceal clubbing or caliectasis); (2) very small kidneys with generalized caliectasis; (3) unexplained nonobstructive dilatation of the upper urinary tract; (4) undue distensibility of the urinary tract; (5) a bladder residue in a child; (6) unexplained renal osteodystrophy. Any of these changes is regarded as an indication for carrying out micturating cystography to establish the presence of reflux.

The relationship between chronic pyelonephritis and reflux is discussed with particular reference to precedence and infection. The implications with regard to treatment are mentioned briefly.

Eight roentgenograms; 10 tracings of pyelograms; 1 table.

THEODORE E. KEATS, M.D.
University of Missouri

Localization of Renal Contrast Media Excretion by Stop Flow Analysis. Marvin W. Woodruff and Richard L. Malvin. *J. Urol.* **84**: 677-684, November 1960. (R. L. M., University of Michigan Medical Center, Ann Arbor, Mich.)

The technic of stop-flow analysis (Malvin et al., *Am. J. Physiol.* **194**: 135, 1958) offers a precise method whereby localization within the nephron of the site of tubular secretion or reabsorption can be determined and graphically displayed. This method was used to locate the nephron site involved in the urinary excretion of Diodrast, Neo-Iopax, Urokon, Hypaque, Miokon, and Renografin. In addition to stop-flow analysis, conventional clearance technics were employed to determine the relative degree of glomerular filtration and tubular secretion of each contrast medium following administration of both trace and pyelographic doses. Twenty studies were made in mongrel dogs.

The findings indicate that Diodrast and Neo-Iopax are handled in the nephron by both glomerular filtration and proximal tubule secretion. At tracer doses of Urokon, one-third is secreted by the tubules. At pyelographic doses, however, tubular secretion decreased to 7-15 per cent, and at still larger doses no tubular secretion was noted, clearance being solely by glomerular filtration. Hypaque, Miokon, and Renografin were handled entirely by glomerular filtration. Small differences between the clearances of these contrast substances and that of creatinine are accounted for by protein binding.

Seven graphs; 4 tables.

IRVING J. WEIGENBERG, M.D.
University of Pennsylvania

THE SPLEEN

Diagnosis of Rupture of the Spleen by Intravenous Abdominal Aortography. Report of a Case. Israel Steinberg and Richard C. Karl. *Am. J. Roentgenol.* **84**: 902-906, November 1960. (New York Hospital, New York 21, N. Y.)

The diagnosis of splenic rupture by conventional roentgenography is based upon signs that, although often helpful, are inconstant, indirect, and nonspecific, depending mostly upon alteration in the position of adjacent structures. Any method which would permit direct visualization of the spleen would facilitate diagnosis, but the use of Thorotrast for this purpose is contraindicated because of its radiation effects. Splenic and hepatic visualization may be obtained with translumbar aortography, but the complications and fatalities associated with this procedure have limited its value. Fortunately, intravenous abdominal aortography readily and safely permits visualization of the spleen, and this technic was utilized by the authors in a case which they report.

A 49-year-old man, admitted to the hospital with respiratory distress one month after an automobile accident injury, was found to have multiple rib fractures of the left lower chest and hemothorax. Thoracentesis afforded considerable relief of dyspnea but failed to alleviate the chest pain, weakness, and weight loss. Roentgen examination showed a left upper quadrant mass with medial displacement of the stomach and downward pressure of the left kidney. Despite normal blood studies and few signs of intra-abdominal hemorrhage, rupture of the spleen was suspected. Prior to surgery, intravenous abdominal aortography was

performed and revealed marked distortion of the splenic artery, enlargement of the spleen, and some extravasation of contrast material into the organ. Operation confirmed the roentgen findings and was curative. The spleen was enlarged to approximately three times normal size, was extremely soft, and contained a large subcapsular hematoma. This case indicates the value of intravenous abdominal aortography, a safe and simple procedure, in establishing the diagnosis of splenic rupture.

Three roentgenograms; 1 photograph.

PHILIP M. JOHNSON, M.D.
Montclair, N. J.

MISCELLANEOUS

Visceral Metastasis from a Meningioma: Report of a Case. Peter B. Hukill and Robert M. Lowman. *Ann. Surg.* **152**: 804-808, November 1960. (Grace-New Haven Community Hospital, New Haven, Conn.)

Meningiomas, though usually benign tumors in their morphology and behavior, occasionally show the histologic characteristics and the growth pattern of malignancy. Nevertheless, it is rare for meningiomas, like intracranial tumors in general, to metastasize outside the central nervous system.

The authors report the case of a 31-year-old woman who, in 1947, began to have moderately severe fronto-occipital headaches, accompanied by vomiting. The symptoms recurred approximately monthly until 1958, when the headache became constant. Skull films showed atrophy of the inner table of the calvarium, following the convolutional pattern. The dorsum sellae was also atrophic, and there was thinning of the left sphenoid ridge. Ventriculography revealed evidence of a space-occupying lesion in the left frontal region. A craniotomy was performed, and a meningioma was removed. Postoperatively, the patient was given x-ray therapy, totaling 4,326 r, through three portals. She was discharged from the hospital with a residual complete motor aphasia and a right hemiparesis. About eleven years later, at the age of forty-three, she returned with a large mass in the right upper abdomen. Laparotomy disclosed a large solitary tumor attached to the left lobe of the liver and many enlarged lymph nodes, measuring 2-3 cm. in diameter, around the superior mesenteric vessels and in the gastrocolic ligament. The patient died in about two months with recurrence of the right upper quadrant mass.

The intracranial and hepatic lesions displayed a strikingly similar and distinctive histologic pattern, leaving little doubt that one was a metastasis from the other. The tumor tissue, composed largely of spindle cells, showed a notable tendency to form angioid structures closely resembling normal blood vessels, suggesting that the tumor was a hemangioblastic neoplasm. It has been designated angioblastic meningioma by Cushing and Eisenhardt. (*Meningiomas: Their Classification, Regional Behaviour, Life History, and Surgical End Results*, 1938).

The authors' case is the twentieth of metastasizing meningioma to be reported, and the fourth of the angioblastic type. Two of the 3 previously recorded cases survived for thirteen years after the original craniotomy and succumbed with metastases, despite the usually rather rapid progress of this tumor. It is possible that tumors of this kind would produce distant metastases more often if the patients lived long enough. Usually

of the splenic
e extravasa
Operation
ative. The
times nor
ned a large
es the value
a safe and
is of splenic

it is the critical location of the primary that leads to death before the tumor has reached the stage where it is capable of metastasis.

One roentgenogram; 1 photograph; 4 photomicrographs.
JOHN P. FOTOPOULOS, M.D.

Northwestern University Medical School

RADIOTHERAPY

Carcinoma of the Endometrium. M. G. Tompkins, F. J. Conklin, and R. B. Thompson. *Canad. M. A. J.* 83: 413-417, Aug. 27, 1960. (Victoria General Hospital, Halifax, N. S., Canada)

The authors undertook a comparative review of 223 patients with carcinoma of the endometrium treated from 1937 to 1957 at the Victoria General Hospital in Halifax, N. S. Of 123 patients treated more than five years prior to this report, 72 lived more than five years (an overall survival rate of 58.5 per cent), and the five-year cure rate (i.e., no recurrence) was 54.5 per cent. Nineteen of the 123 patients received preoperative irradiation; 15 (79 per cent) lived five or more years. The radiation technic is not described. In 72 cases the primary attack was surgical; 48 (66.7 per cent) patients survived more than five years, with and without postoperative irradiation. The surgery included both

abdominal and vaginal hysterectomy and was usually accompanied by bilateral salpingo-oophorectomy. Before 1953, 32 women were treated by radiotherapy alone. This group was heavily loaded with patients whose disease was so far advanced when they were first seen that surgery was deemed inadvisable or useless. Of the entire group only 9 (28 per cent) lived more than five years.

The recurrence rate among the 217 treated patients was 13.8 per cent (30 patients) and was closely associated with the extent of tumor involvement when the patient was first seen.

Preferential therapy consists of insertion of radium in multiple or single tandems, followed by complete surgery in six weeks.

Twelve tables.

DAVID SILVER, M.D.
Los Angeles, Calif.

RADIOISOTOPES

Determination of the Cardiac Output by External Detection of Radioactivity of the Aortic Blood (Human Serum Albumin Tagged with I¹³¹). P. Marquès, J. Géraud, A. Bru, and A. Bes. *J. de radiol.* 41: 547-553, October 1960. (In French) (Toulouse, France)

The authors report their experience with a technic of ascertaining the cardiac output by external detection of the radioactivity of the aortic blood. The tracer, human serum albumin tagged with I¹³¹, is injected into the antecubital vein. The dilution curve is directly registered by a scintillation counter placed at the aortic knob; the output is calculated with the help of a modified Hamilton equation and requires the simultaneous determination of the total blood volume.

The results obtained are similar to the values given by the classical methods. This simple technic, readily accepted by the patients, permits easy and, if needed, repeated determinations of the cardiac output and extends the indications of this interesting investigation.

Two graphs; 2 tables. RENÉ HOURI, M.D.
New York, N. Y.

Analysis of Cardioportal Circulation Time by Means of Simultaneous Direct Hepatic Venous Counting. Ismael Mena, Leslie R. Bennett, Telfer B. Reynolds, Allan G. Redeker, and Sherman M. Mellinkoff. *New England J. Med.* 263: 940-943, Nov. 10, 1960. (L. R. B., University of California at Los Angeles School of Medicine, Los Angeles, Calif.)

The cardioportal circulation time is determined by the simultaneous external recording over the heart and liver of the passage of an intravenously injected radioactive bolus. For this purpose the authors inject 0.3 millicurie of I¹³¹-tagged sodium acetazotate per kilogram of body weight into an antecubital vein. Thirty-six normal subjects and 101 patients with hepatic cirrhosis were studied.

In the normal subjects the cardioportal circulation time averaged twenty-five seconds.

The mean cardioportal circulation time was forty-six

seconds in 52 cirrhotic patients; it was 17.7 seconds in 9 patients with portacaval shunts; 17.8 seconds in 13 patients with intractable ascites; 29.5 seconds in 10 patients with moderately tractable ascites; 45.7 seconds in 11 patients with easily tractable ascites; nineteen seconds in 6 critically ill patients with minimal ascites but severe progressive jaundice.

It was concluded that cardioportal circulation time is prolonged in patients with cirrhosis of the liver and portal hypertension. When the hepatic cirrhosis is associated with severe ascites and other grave signs of liver disease the cardioportal circulation time is surprisingly short despite the presence of portal hypertension. This shortened time is explained by the possible shunting of portal blood through the diseased liver by venovenous anastomoses and by possible additional shunting of portal blood away from the liver cells through extrahepatic collateral channels.

Three graphs. MORTIMER R. CAMIEL, M.D.
Brooklyn, N. Y.

Application of Radioisotopes to the Study of Proteins. R. A. Collet. *Schweiz. med. Wochenschr.* 90: 1163-1164, Oct. 15, 1960. (In French) (Laboratoire central de l'Hôpital cantonal de Genève, Switzerland)

In recent years radioactive tracer studies have assisted in the chemical investigation of protein molecules. For labeling proteins with tracer substances the following two prerequisites are postulated: 1. The isotope must not alter the properties of the proteins. 2. The same isotopes must not be used again for the synthesis of new proteins.

Investigations have included: (a) determination of blood volume with radioiodine, (b) study of hemoglobin with radiochromium, and (c) of the plasma protein with radio-iron.

For determination of blood volume small quantities of albumin are labeled with radioiodine. The solution mixes rapidly with the circulating plasma, so that fifteen

minutes after injection the blood can be tested for radioactivity which determines hematocrit values.

For hemoglobin values 50 mg. of radiochromium is injected intravenously. Specimens are taken, and half-life values are ascertained in test tubes. Under favorable conditions 90 per cent of the isotope can be fixed to the hemoglobin. The solution remains stable for a long time so that its half-life can be easily determined. In normal cases it is twenty-six days while in hemolytic anemia it is only ten days.

For plasma determination radioiron is injected intravenously. This becomes readily fixed to β_1 -globulin, provided the latter is not yet saturated with iron.

Since radioactive detectors are very sensitive, laboratory technics must be extremely accurate for prevention of misleading results. ERNEST KRAFT, M.D., Northport, N.Y.

Carcinoma of the Prostate: Treatment by Interstitial Irradiation with Radioactive Gold—Experimental and Clinical Studies. George J. Bulkley and Vincent J. O'Conor. *J.A.M.A.* 174: 252-256, Sept. 17, 1960. (Wesley Memorial Hospital, Chicago, Ill.)

Interstitial irradiation of the prostate by means of radioactive gold appears to have a highly selective use in the management of prostatic carcinoma. Selectivity would include those patients with localized areas of carcinoma for whom the palliative effect may be worthwhile. Evaluation in this series of 42 patients treated from 1953 to 1957 would be difficult since all of the patients received estrogen therapy and almost one-half of the group underwent orchiectomy. Nineteen died of prostatic carcinoma, with autopsies showing shrinkage of the tumor in only 3 cases. Seventeen of the 20 living patients have improved with noticeable softening of the mass and with temporary arrest of the carcinoma in 10 and its complete arrest in 7.

Two photographs; 3 photomicrographs; 3 tables.

DAVID SILVER, M.D.,
Los Angeles, Calif.

The Diagnosis and Management of Myelofibrosis, Myelosclerosis and Chronic Myeloid Leukemia. A. Goldberg and D. A. Seaton. *Clin. Radiol.* 11: 266-270, October 1960. (Western Infirmary, Glasgow, Scotland)

Four cases of myelofibrosis and myelosclerosis and 4 of chronic myeloid leukemia are compared in respect to clinical features, hematologic and radioisotopic (radioiron and radiochromium) investigations.

The two diseases present a similar clinical picture, but may be differentiated by blood and bone-marrow studies. The mechanism of the anemia in these conditions is the same, namely, a combination of marrow hypoplasia and increased hemolysis. The spleen may or may not be the site of extramedullary erythropoiesis in either condition; it may be the site of erythrocyte destruction. Radioisotopic investigations proved helpful when splenectomy and splenic irradiation were considered in the treatment of myelofibrosis.

Occasionally the differential diagnosis of chronic myeloid leukemia from myelofibrosis and myelosclerosis can be made on radiologic grounds. Radiologically demonstrable changes are rare in chronic myeloid leukemia but are present in about half the cases of myelofibrosis and myelosclerosis. Briefly, these are widening and increased density of the trabeculae, ill-defined areas of sclerosis and osteoporosis and later obliteration of the

medullary cavity by new-bone formation. These changes occur most commonly in the central parts of the skeleton, e.g., the vertebral bodies and the upper ends of the femora and humeri.

Four graphs; 2 tables.

THEODORE E. KEATS, M.D.,
University of Missouri

The Present Position of Telecobalt Therapy. E. Zdansky. *Radiol. clin.* 29: 334-346, November 1960. (In German) (Universitätsinstitut für Röntgeniagnostik und Strahlentherapie, Basel, Switzerland)

Radioactive cobalt presents certain advantages over conventional roentgen therapy. These include greater depth dose, maximum dose beneath the skin surface, smaller integral dose for similar effects, more accurate field distribution, and more equal distribution in various tissues such as soft tissue and bone. Mucous membranes show less reaction with cobalt therapy and necrosis of bone seldom occurs.

Multiple fields are preferred to rotation therapy, especially in the head and neck. Complications are seldom seen in laryngeal carcinoma if a maximal dose of 6,000 to 7,000 r in fifty to sixty days is not exceeded. With a short target-skin distance large doses can be given to parotid and ear tumors without excessive depth effects. This is also true of the superficial tissues in breast carcinoma.

Four figures.

CHARLES M. NICE, JR., M.D., Ph.D.,
Tulane University

Complications of Telecobalt Therapy. Raymond Sarasin. *Radiol. clin.* 29: 346-356, November 1960. (In French) (Hôpital universitaire de Genève, Switzerland)

To obtain the same biological effect on tumor tissue with cobalt therapy as with conventional irradiation, it is necessary to give a 15 to 20 per cent greater tumor dose in the former. Greater doses, however, even up to 8,000 r or higher, may be used in the cobalt treatment.

In general, the complications of high-energy therapy are similar to those of conventional therapy, although skin and mucosal reactions are less severe with the higher energies. Necrosis in the tumor and the interstitial tissues depends on the extent of the tumor. In treatment of carcinoma of the esophagus or bronchus, preoperative therapy with 4,000 to 5,000 r tumor dose is given in five to seven weeks. Surgery is then delayed three or four weeks, when the tumor is smaller and easier to remove surgically.

Careful dosimetry and follow-up of patients with tumors in the pelvic region is necessary if the usual complications of radiotherapy are to be avoided.

CHARLES M. NICE, JR., M.D., Ph.D.,
Tulane University

The Design of a Second Cobalt 60 Unit, Based on the Experience Acquired with 1,000 Patients Treated with the First Unit. Gilbert H. Fletcher, Ernest J. Braun, E. B. Moore, and Earl van Roosenebeek. **Appendix: A Dose-Time Calculator for Roentgen- and Gamma-Ray Beams.** Ernest J. Braun, Earl van Roosenebeek, and R. J. Shalek. *Am. J. Roentgenol.* 84: 761-770, October 1960. (M.D. Anderson Hospital and Tumor Institute, Houston 25, Texas).

Reasons for the acquisition of a second cobalt unit and parameters of supervoltage therapy are discussed.

as are four main characteristics of supervoltage therapy: skin sparing, considerable increase in depth dose, minimal integral dose, and decrease in differential bone absorption. One 22-Mev betatron was considered adequate for those cases in which treatment with it was indicated. The 2-Mev roentgen-ray generators had all the requirements except a gantry type mechanism. The foreign 4-Mev linear accelerators would have been considered if they had been economically available and serviceable in this country.

Analysis of tabulated figures indicates that the following tumors are preferably treated with cobalt 60: tumors of the head and neck and of the breast; lymphoma; tumors of the testes. The cervix and urinary bladder are preferably treated with the 22-Mev betatron.

The third supervoltage unit desired by the group at M.D. Anderson Hospital had to have a beam similar to the 2-Mev roentgen-ray generators, a suspension mechanism for maximum speed and accuracy of positioning, large field size for segmental therapy, and a collimating device producing minimum penumbra and allowing field shaping.

Limited space and the desire for a rotating suspension type mechanism were the primary reasons for acquiring a second kilocurie cobalt-60 unit with the following characteristics: (1) a high activity source of 3,000 curies, rendering 70 cm. S.S.D. still practical for large field therapy; (2) a suspension mechanism allowing stationary portals or rotation therapy; (3) minimal penumbra and field shaping. Features of this new unit discussed in detail are: the suspension mechanism; degrees of motion; collimating device; auxiliary diaphragms; calibration tables; such accessories as special head rests, plastic tray, lateral film holder, and wedge filters.

Ten figures; 1 table.

An appendix on the article describes dose-time calculators for roentgen and gamma-ray beams which are used for quick calculations on the cobalt-60 and 250-kv units at the M.D. Anderson Hospital. The calculators are of the usual plastic circular disk variety.

Five figures.

DAVID SILVER, M.D.
Los Angeles, Calif.

Radioactive Strontium in Bone Disease. R.-A. Guérin and Mme. M.-T. Guérin. *Presse méd.* 68: 1575-1576, Oct. 1, 1960. (In French) (M.-T.G., Institut national d'hygiène, Paris, France)

Strontium has a metabolism very near to that of calcium. Among its numerous radioactive isotopes, Sr⁸⁵ and Sr⁸⁹ have physical properties compatible with clinical applications.

Only Sr⁸⁵ is usable for diagnostic purposes in bone tumors and in the prognosis of fractures of the femoral neck. Thirty-four patients were tested with this isotope and the method is painless. The authors feel that the observed results should authorize a wider application of the technic.

Sr⁸⁵ is not curative, however. The only results obtained from its administration were a sedative effect on pain in a few rare cases, especially in multiple myeloma.

RENÉ HOURI, M.D.
New York, N. Y.

Osseous Fixation of Strontium and of Gallium: Clinical Applications. F. Coste, F. Layani, Mme. M.-T. Guérin, and R.-A. Guérin. *Rev. du rhumat.* 26:

733-738, December 1959. (In French) (M.-T.G., Institut national d'hygiène, Paris, France)

In vivo and *in vitro* comparisons were made of the osseous fixation of strontium 85 and gallium 67 in the guinea-pig. It was found that strontium has a more selective affinity for bone tissue than gallium and is easier to detect by means of external measurements. The doses needed for an exploration are only half the amounts required for gallium and the longer period of activity enables fixation to be followed with the aid of repeated measurements. There seems to be hope that the use of this isotope in man will enable the tests carried out to be interpreted more easily and more accurately.

Studies on the uses of the isotope are continuing.

Radioactive Sulphur in Chondrosarcoma. The Distribution, Concentration, and Effects of S³⁵ After Intravenous Administration to Patients with Chondrosarcoma. Raymond G. Gottschalk. *J. Bone & Joint Surg.* 42-A: 1239-1256, October 1960. (VA Center, Martinsburg, W. Va.)

Radioactive sulfate is selectively retained in chondrosarcomas, chondromas, and normal cartilage as well as in repairing connective tissue and bone. This paper reports studies on the localization and concentration of tracer amounts of radioactive sulfur (S³⁵) in 5 patients with chondrosarcomas and in 1 with an anaplastic sarcoma, and a therapeutic trial of large amounts of the isotope in 3 patients with advanced chondrosarcomas. The sulfur was administered as a solution of sodium sulfate (Na₂S³⁵O₄) in neutral physiological saline through the tubing of an intravenous-drip apparatus.

The concentrations of the tracer amounts observed in various tissues at increasing intervals after injection are tabulated, the average concentrations in the chondrosarcomas varying from 62 to 440 per cent of the concentrations found in normal cartilage. Uptakes higher than average were found in the growing portions of the tumors. The fixation of S³⁵ seemed to result from both the formation of cartilaginous ground substance and the increased metabolism of neoplastic cells. The pleomorphic sarcoma, almost devoid of ground substance, contained less S³⁵ than the chondrosarcomas studied after similar intervals. The autoradiographs from these patients showed that the isotope was deposited near metabolically active cells of cartilage and of chondrosarcomas. It was fixed near well preserved chondrocytes in the chondromas and was deposited at the sites of proliferation of connective tissue in the capsules of tumors and in inflammatory tissues.

The chemical analyses demonstrated grossly and the autoradiographs showed microscopically the deposition of S³⁵ in proliferating areas of mesenchymatous structures and, to a higher degree, in chondrosarcomas. This favorable pattern of distribution could be put to therapeutic use only if the injection of large amounts of S³⁵ resulted in sufficient concentrations in the tissues to have biological effects. The effects of large amounts were therefore studied in 3 patients with advanced chondrosarcomas. Bone-marrow depression was the limiting factor in determining the total dose, which varied from 559 to 926 millicuries. Although somewhat higher doses were occasionally used, it seemed advisable not to exceed 200 millicuries per injection at intervals of one to four weeks. The progress of the neoplasms seemed markedly reduced or arrested for several months in 2 of these patients. Despite the im-

portant uptake of S^{35} in repairing connective tissue, there was no evidence of interference with wound healing. No symptoms referable to any joints were noted. Leukopenia was not accompanied by symptoms of radiation sickness. The calculated doses of radiation internally delivered by the isotope to the chondrosarcomas were much higher than those delivered to other tissues.

The author concludes that it will be necessary to observe the effects of large amounts of S^{35} on a greater number of chondrosarcomas to determine whether a significant palliation can be obtained in a sufficient

number of cases to warrant its clinical use. As with other radioactive isotopes and with some chemotherapeutic agents, the amounts of radioactive sulfur that can be administered are limited by the hematological effects. Since the development of severe leukopenia and thrombocytopenia may be delayed for two or three weeks after the administration of S^{35} , the use of large amounts of S^{35} can be justified only in cases of far advanced tumors.

Nine figures; 3 charts; 2 tables.

CAPT. SAMUEL S. KRIKORIAN, M.C.
Lackland AFB, Texas

RADIATION EFFECTS

A Study of Complications in the Surgical and Radiation Therapy of Cancer of the Cervix. Henry Clay Frick, II, Howard C. Taylor, Jr., Ruth J. Guttmann, Harold W. Jacox, and William P. McKelway. *Surg., Gynec. & Obst.* 111: 493-506, October 1960. (College of Physicians and Surgeons, Columbia University, New York 32, N. Y.)

At the Presbyterian and Francis Delafield Hospitals (New York), during the years 1944 to 1957, 748 patients with primary carcinoma of the cervix were treated by the following methods: (1) external roentgen rays alone, 82 patients; (2) intracavitary radium and external roentgen rays, 272; (3) radium needles and external roentgen rays, 119; (4) intracavitary radium, external roentgen rays, and lymph node dissection, 56; (5) radical operation, 92; (6) radical operation and external roentgen rays, 115; (7) other, 12. Certain changes in the management of cervical carcinoma were made in late 1951 and early 1952; for that reason, the series is reported in two periods, 1944 to 1951 and 1952 to 1957. From 1952 to 1957 some patients underwent extraperitoneal node dissection after full radium and external roentgen therapy. Supervoltage therapy was introduced, and the tumor dosage of external radiation was gradually increased from 2,500-3,000 r given over a period of four weeks to about 6,000 r in four to six weeks.

The 748 cases are reviewed with particular attention to the complications. These are considered in three categories, namely, radiation injuries, surgical injuries, and those due to a combination of the two. It appears that in recent years there has been a greater number of fatalities and severe complications. This is attributed to an increase in the dosage of external roentgen therapy; to the combination of surgical therapy with irradiation, as in the group treated by extraperitoneal node dissection after full irradiation; and to a less strict selection of patients for operation.

With the advent of supervoltage apparatus, an increase in roentgen therapy dosage was made possible. This increase was superimposed on an established radium procedure originally designed to give what was believed to be the maximum dosage which could be tolerated by the rectum and bladder. In a group of 65 patients managed by radium plus external radiation in excess of 4,000 r to the pelvis, there were 4 deaths and 5 major complications. In a similar group of 40 patients treated with less than a 4,000 r tumor dose, there were 2 major complications and 2 deaths, both unrelated to the roentgen therapy.

Similar differences were found in the group treated by extraperitoneal node dissection after radiotherapy.

Of 39 patients who received radium and more than 4,000 r by roentgen therapy to the pelvis, 2 died, and major complications developed in 14. Fourteen patients received identical treatment except that they were given less than a 4,000 r tumor dose; in this group there were 3 major complications and 1 death, the latter a direct result of the surgical procedure.

An increase in surgical complications is perhaps less apparent. Nevertheless, from 1944 to 1951, there were 8 major complications in 65 patients, with no deaths, as compared with 21 major complications and 3 operative deaths in 113 patients treated in the later period. There was not much change in the incidence of ureterovaginal fistula in the two periods.

The hope that a higher cure rate may be obtained by subjecting patients to higher and higher dosages of external irradiation appears to be sharply limited by the tolerance of normal tissues to these high dosages.

Two photomicrographs; 14 tables.

ROBERT E. CAMPBELL, M.D.
University of Pennsylvania

Radiation Ileitis. Robert Henry Abrahamson. *Arch. Surg.* 81: 553-557, October 1960. (107 Glenbrook Road, Stamford, Conn.)

The subject of radiation injury to the ileum is reviewed, including the summary of Mulligan (Am. J. Path. 18: 515, 1942. Abst. in Radiology 40: 431, 1943), who cited cases reported by Walsh in 1897. Abdominal and pelvic radiation is frequently administered after laparotomy. In some of these cases adhesions will form, holding the ileum immobile. Even intensive radium application to the cervix may cause adhesion of the small intestine when it is in the pelvis. Under these conditions, the immobilized loop will receive a higher radiation dose than loops which do not maintain a fixed position, especially when high-energy (multiport cobalt) irradiation is combined with radium in the cervix. Symptoms are extremely variable, from the hyperacute phase to those resulting from chronic obstruction, dependent on the pathological status of the intestine. Following recovery from the acute phase, the patient may be asymptomatic for long periods, after which gastrointestinal symptoms recur. The diagnosis is often obscure until obstruction supervenes. The only definitive treatment is surgical excision.

A case is reported in which 10 different diagnoses were made over a twenty-year period prior to surgery with relief of obstruction and a positive diagnosis of focal ulcerative and cicatrizing ileitis due to radiation effects. Radiation had been given at Memorial Hospital, New York (3,000 mc per hour of radium

use. As with the chemotherapy, a sulfonamide was used for the hematological changes. Leukopenia was present in two or three cases of far advanced disease.

Radiation ileitis should be considered when acute and chronic gastrointestinal derangements follow irradiation of the abdomen and pelvis.

Three photomicrographs; 1 table.

Incidence of Leukaemia After Exposure to Diagnostic Radiation in Utero. W. M. Court Brown, R. Doll, and A. Bradford Hill. *Brit. M. J.* **2**: 1539-1545, Nov. 26, 1960. (W. M. C. B., Medical Research Council's General Effects of Radiation Research Unit, Western General Hospital, Edinburgh, Scotland)

In order to investigate the possible leukemogenic effect of fetal irradiation, the authors checked the names of 39,166 children who had been irradiated *in utero* between 1945 and 1956 in 8 metropolitan hospitals against the Registrars-General lists of names of children who died of leukemia between 1945 and 1958. The data obtained were then compared with the corresponding sex- and age-specific national leukemia rates.

The expected number of deaths from childhood leukemia was 10.5; the observed number was 9. Of these 9 cases, in 4 irradiation had been received during pelvimetry and in 5 during a single roentgenogram of the maternal abdomen. Only 12 per cent of the children had been irradiated during the first 2 trimesters of pregnancy. There was no evidence of a greater incidence of leukemia in the children most heavily irradiated *in utero*. The male-female ratio was increased to 1.15:1 from the national average of 1.06:1. The most likely explanation for this would be that the risk of a complicated delivery (one of the reasons for radiographic examination during pregnancy) is higher for boys.

The authors concede that their methods may have failed to detect 2 to 3 per cent of the true number of leukemia deaths, but they note that even if 10 per cent of these deaths were undiscovered the observed incidence of leukemia among the irradiated children would not exceed the national average. If the effect of *in utero* irradiation were to raise the incidence of leukemia by 100 per cent, this rise would, with high probability, have been detected by the study; however, an increment of 50 per cent might have remained undetected.

Published data on the leukemogenic effect of irradiation *in utero* are conflicting, but the authors believe that an increase of leukemia among children due to radiographic examination of the mother's abdomen during the relevant pregnancy is not established.

Seven tables. PHILIP M. JOHNSON, M.D., Montclair, N. J.

Leukemia Following Radioiodine Treatment of Thyrotoxicosis. E. Eric Pochin. *Brit. M. J.* **2**: 1545-1550, Nov. 26, 1960. (Medical Research Council Department of Clinical Research, London, England)

Approximately 60,000 thyrotoxic patients have been treated with radioiodine in the United Kingdom, the United States, Canada, and Austria during the last twenty years. Leukemia is known to have developed subsequently in 18 of these patients. An attempt was made by questionnaire to determine (1) the number of cases expected on a purely chance basis, and (2) the total number of cases that have in fact occurred.

No previously unknown case of leukemia was found among an estimated total of 59,200 treated patients representing 221,900 patient-years at risk. The num-

ber of cases of leukemia expected on the basis of chance alone was 21.2, figure compatible with 14 to 28 actual cases. Although this estimate is only approximate, determination of the true figure is "less urgent" since presently known cases of leukemia do not exceed the chance expectation. The intervals between initial treatment with radioiodine and subsequent diagnosis of leukemia in the 18 known cases ranged from three months to eight years and were consistent with a chance distribution. The leukemia was acute in 13 cases, chronic in 4, and the type was not ascertained in 1 instance.

The author concludes that his data appear to give no indication that treatment of thyrotoxicosis with radioactive iodine induces leukemia. He warns against misinterpretation of future reports of leukemia in patients so treated, since the number of naturally occurring cases of leukemia will inevitably increase as the number of patient-years at risk grows.

Four figures; 8 tables. PHILIP M. JOHNSON, M.D., Montclair, N. J.

Leukaemia in Childhood After Antenatal Exposure to X Rays: A Survey at Queen Charlotte's Hospital. T. L. T. Lewis. *Brit. M. J.* **2**: 1551-1552, Nov. 26, 1960. (Queen Charlotte's Hospital, London, England)

Data recently compiled by Stewart *et al.* (*Lancet* **2**: 447, 1956; *Abst. in Radiology* **69**: 159, 1957; *Brit. M. J.* **1**: 1495, 1958; *Abst. in Radiology* **72**: 634, 1959) suggested the remote possibility of leukemia or other malignant disease developing subsequent to antenatal irradiation. Analysis of the data in Stewart's two series, however, indicates that such irradiation cannot cause more than 1 case of leukemia in 40,000 births. To substantiate this analysis the author determined the number of children dying of leukemia before the age of ten who had been born in Queen Charlotte's Hospital during 1943 to 1958. There were 45,195 live births at that hospital during this period, and 25.3 per cent of the infants had been irradiated *in utero*, as compared with about 16 per cent of the pregnant women in England and Wales during the same period. Eight deaths from childhood leukemia were found; due to errors in the method of data collection the true figure may have been 10 cases. Of these 8 children, 1 had received antenatal irradiation; he was exposed to one erect lateral view of the abdomen near term. The incidence of death from leukemia was 1 in 1,808 among children receiving no antenatal irradiation and 1 in 4,291 among children irradiated *in utero*.

The incidence of leukemic deaths among children born in Queen Charlotte's Hospital is slightly higher than for the country as a whole, but this is due to the much higher incidence of leukemic deaths among the nonirradiated (control) group and cannot, therefore, have been caused by irradiation.

The author concludes that, due to the relative paucity of his data, the tendency of antenatal irradiation to cause only 1 case of leukemia in 40,000 live births is unproved. The true tendency, however, cannot be very much greater. PHILIP M. JOHNSON, M.D., Montclair, N. J.

Diagnostic X-Ray Exposures: The Middle Road. Donald L. McRae. *Canad. M. A. J.* **83**: 929-933, Oct. 29, 1960. (Montreal Neurological Institute, McGill University, Montreal 2, Quebec)

For over sixty years, x-rays have been used in the

practice of medicine and have proved invaluable, even life-saving, in some cases. Recently there has been a storm of publicity over the allegedly harmful effects of small amounts of radiation. To answer patients' questions, doctors must know the facts about the effects of small amounts of radiation on man.

Doses of 5 rads of x-irradiation are entirely safe for a patient, and there need be no fear of diagnostic roentgen examinations, therefore, provided that they are done with modern machines and modern techniques.

Gonadal doses due to diagnostic roentgenology in areas other than the lower abdomen and pelvis are negligible with reasonable care and modern techniques.

In examinations of the lower abdomen and pelvis in patients below the age of forty, the patient should trust the good judgment of his radiologist and his personal physician to decide whether or not the benefits of such a study outweigh the debatable, distant genetic effects of the necessary small amount of gonadal exposure.

Although there is no evidence that small x-ray exposures are harmful to man, it is conceivable that some genetic effect may be shown in future work. For this reason the efficiency of roentgen, and especially of dark-room, techniques must be increased to reduce the dose from primary and secondary radiation as much as possible.

Hazards of Bladder Surgery Following Irradiation. Anthony Walsh. *J. Urol.* 84: 627-629, November 1960. (St. Luke's Hospital, Dublin, Eire)

Intravenous pyelography in a 47-year-old white male with intermittent, slight, painless hematuria of twelve months duration demonstrated a normal upper urinary tract and an indefinite central filling defect of the bladder. The patient was otherwise a fit, healthy man of excellent nutrition and in good general condition. Cystoscopy, biopsy, and resection (Nov. 29, 1957) confirmed the diagnosis of 2 papillary transitional-cell tumors of the bladder.

On Feb. 25, 1958, 7 new papillary bladder tumors were found and resected. Histologically, these tumors were definitely more anaplastic than those of the first resection. Deep x-ray therapy, a tumor dose of 4,200 r and a maximum skin dose of 3,800 r, was given over a period of five weeks but was terminated because of severe reaction in the left testicle and scrotum. On May 18, ten or more bladder lesions were found. Radical cystectomy was performed on Aug. 15. The ureters were implanted into an ileal loop and the loop was joined, end to end, to the posterior urethra. The postoperative course was stormy; the anastomosis of the ileal loop and urethra opened and was refashioned in a second operation on Aug. 20. On Sept. 5 an intravenous urogram showed the right kidney functioning normally with no dilatation; delayed excretion and moderate pyelectasis at twenty-five minutes were demonstrated in the left. The right ureter appeared normal but the left was moderately dilated as far as the sacroiliac joint and was not seen below this. With progressive decrease in the amount of urinary drainage from the catheter and corresponding increase in the leakage from the abdominal wound, the patient's general condition continued to deteriorate and he died on Sept. 18.

Autopsy revealed all three anastomotic sites—urethral-ileal, ureteral-ileal, and end-to-end anastomosis in the ileum—to have broken down. It seemed quite

clear that the failure of union must be attributed to the previous radiotherapy.

The author concludes that the hazards of radical cystectomy are greatly enhanced by previous irradiation. If radical cystectomy after radiation therapy is done, a pouch-urethra anastomosis has little chance of success because the bladder base and prostate receive the maximum radiation. Whether the ureters are implanted in isolated ileal loops or colon they should be divided at or above the pelvic brim to avoid the use of previously irradiated portions of the ureters for anastomosis. Further, the anastomotic suture line should be reinforced by an outer layer of non-absorbable suture material.

CORINNE FARRELL, M.D.
University of Pennsylvania

Osteoradiationcrosis of the Mandible. W. Röhr and F. Flöte. *Fortschr. a. d. Geb. d. Röntgenstrahler* 93: 472-482, October 1960. (In German) (Stadt Krankenhaus, Berlin-Westend, Germany)

From 1950 until 1957 the authors observed 10 tumors of the oral cavity, in 15 of which (7.8 per cent) mandibular necrosis developed. Seven patients were treated with roentgen rays alone and 8 with interstitial radiation followed by roentgen rays.

With increasing frequency of larger doses of ionizing rays, necrosis of bone occurs more often. Dentistry also stimulates mucosal ulceration and infection of the underlying mandible with the end-result of necrosis and sequestration of bone. Other contributing factors to bone damage are continuous trauma from chewing and loss of the protective effect of saliva due to radiation-induced drying-up of the mucosa.

In the observed cases osseous necrosis became manifest from eight months to nine years after radiotherapy. The roentgen signs were preceded by long-standing soft-tissue swelling and subsequent ulceration of the oral mucosa. In the early phase the radiographic findings were osteoporosis and irregular contour of the mandible. This was followed by destructive changes from the alveolar ridge downward, osteolysis and debris, and finally pathologic fractures with sequestration.

Prophylactic measures are the most effective treatment. High-voltage roentgen rays are given preference as causing less bone destruction than those of low voltage. Another preventive measure is the insertion of radium needles at an angle instead of parallel to the mandible. Hygiene of the mouth has to be carefully observed and remaining teeth have to be extracted under penicillin prophylaxis several weeks prior to radiotherapy. Occasionally extractions may have to be postponed until completion of therapy.

Treatment of mandibular necrosis is not guided by roentgenographic findings or the presence of ulcers. Local and general antibiotic measures together with frequent washing tend to expedite the cure of ulcers and fistulae. Sequestra usually protrude spontaneously. The mucosa heals promptly in spite of underlying osseous necrosis and pathologic fractures. Sequestrectomy with the aid of antibiotics, modern anesthesia, and blood transfusions has become a routine procedure. It expedites the healing process and prevents development of fistulae and ulcers. A well functioning prosthesis can now be fitted even in advanced cases.

Thirteen roentgenograms: 5 photographs: 4 tables
ERNEST KRAFT, M.D.
Northport, N.Y.

ibuted to the

ods of radical
ious irradiation
on therapy is
the chance of
prostate receive
reters are in
they should be
void the use of
ars for anasto
ine should be
erbable suture
ELL, M.D.
nsylvania

W. Röhr
ntgenstrahlen
man) (Stadt
)

observed 18
(7.8 per cent)
patients were
th interstitial

es of ionising
ten. Dental
and infection
end-result of
or contributing
trauma from
saliva due to
a.

became man
radiotherapy,
long-standing
ration of the
ographic find
ontour of the
active changes
sis and debris
stration.

ffective treat
e given prior
than those of
are is the
ead of parallel
th has to be
have to be
al weeks prior
s may have

not guided by
ence of ulcers
together with
e of ulcers and
spontaneously
underlying os

Sequestre
nesthesia, and
procedure. It
s development
ing prosthesis

phys: 4 tables
RAFT, M.D.
port, N.Y.